UNITED STATES
DEPARTMENT OF THE INTERIOR

DRAFT
ENVIRONMENTAL STATEMENT

VOLUME 1 OF 2

Proposed
1974 OUTER CONTINENTAL SHELF
OIL AND GAS GENERAL LEASE SALE
OFFSHORE LOUISIANA

OCS SALE No. 36

DES 74- 49

Prepared by the
BUREAU OF LAND MANAGEMENT

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Director

Summary

(X) Draft ( ) Final Environmental Statement
Department of the Interior, Bureau of Land Management
Division of Marine Minerals

1. Proposed Oil and Gas Lease Sale, Outer Continental Shelf Gulf of Mexico
   (X) Administrative ( ) Legislative Action

2. Two hundred and ninety-five tracts (1,421,739.13 acres) of OCS lands are proposed for leasing action. The tracts are located offshore Louisiana; seventy-two tracts (403,969 acres) are situated in water depths of 200 meters or beyond. If implemented, this sale is tentatively scheduled to be held in the late fall of 1974.

3. All tracts offered pose some degree of pollution risk to the environment and adjacent shoreline. The risk potential is related to adverse effects on the environment and other resource uses which may result principally from accidental or chronic oil spillage. Each tract offered is subjected to a matrix analytical technique in order to evaluate significant environmental impacts should leasing and subsequent oil and gas exploration and production ensue.

4. Alternatives considered:

   A. Hold the Sale in Modified Form
      1. Delete Tracts
      2. Substitute Tracts

   B. Withdraw the Sale
      1. Energy Conservation
      2. Conventional Oil and Gas Supplies
      3. Coal
      4. Synthetic Sources of Oil and Gas
      5. Hydroelectric Power
      6. Nuclear Power
      7. Energy Imports
      8. Other Energy Sources
      9. Combination of Alternatives

   C. Delay the Sale

D. Government Exploratory Drilling Before Leasing

5. Comments have been requested from the following:

Environmental Protection Agency

Department of Commerce
National Oceanic and Atmospheric Administration

Department of Defense

Department of Transportation
U.S. Coast Guard

Department of the Treasury

Atomic Energy Commission

Federal Power Commission

State of Louisiana
Commission on Intergovernmental Relations

State of Alabama
Alabama Development Office

State of Mississippi
Coordinator for Federal-State Programs

State of Texas
Office of the Governor

Department of the Interior
Bureau of Sport Fisheries and Wildlife
Bureau of Outdoor Recreation
Bureau of Mines
Geological Survey
National Park Service

6. Draft statement made available to Council on Environmental Quality and the public on May 1, 1974.

TABLE OF CONTENTS

VOLUME I

	Page
I. DESCRIPTION OF PROPOSAL	1
A. Location and Reserves	1
B. Relationship of This Proposed Action to Existing and Prospective Offshore Oil and Gas Development in the Gulf of Mexico.	3
C. Background of Proposal.	8
D. Proposed Five-Year Schedule - Provisional OCS Leasing . .	13
E. Activity, Environment, and Impact from the Five-Year Schedule in the Gulf of Mexico.	16
1. Proposed Sale	16
2. Development	16
3. Environment	16
4. Resource Use and Commercial Activity Related to the OCS in the Gulf of Mexico	22
5. Possible Environmental Impacts from OCS Oil and Gas Development Resulting from Implementation of the Five-Year Lease Schedule.	29
F. Tract Selection	30
1. Responsibilities and Procedures	30
2. Purpose of the Tract Selection Process.	32
3. Selection of Royalty Tracts	34
G. Contract, Research and Study Programs	35
1. Introduction.	35
2. Studies on OCS Practices and Technology	35
3. Ongoing Contracts and Inhouse Efforts	44
4. Planned Study Efforts - FY '74.	48
5. Additional Study and Research Programs - FY '75 . . .	49
II. DESCRIPTION OF THE ENVIRONMENT	
A. Geologic Framework.	52
1. General	52
2. Geologic History and Structure of the Gulf of Mexico	52
3. Surface Sediments	67

Table of contents (cont')

Page

4. Geologic Hazards. 71
5. Oil and Gas Production. 78

B. Climate of the North Central Gulf of Mexico and Adjacent Coastal Zone 82
1. Barometric Pressure and Atmospheric Circulation . . 82
2. "Northers". 86
3. Precipitation 86
4. Humidity, Cloudiness and Fog. 88
5. Temperature 90
6. Storms. 92

C. Physical Oceanography 104
1. Surface Circulation 104
2. Surface Sea Temperatures. 108
3. Salinity. 111
4. Tides 111
5. Sea State 113

D. Biology of the Coastal Zone 117
Introduction to the Marshes 117
1. The Salt Marsh. 135
2. The Brackish Marsh. 143
3. The Intermediate Marsh. 146
4. The Fresh Marsh 148
5. Barrier Islands 154
6. Fauna of the Marshes and Barrier Islands. 163
7. Seagrasses. 182
8. Estuaries and Embayments. 185

E. Biology of the Offshore Environment 192
1. The Environment 192
2. Communities and Food Webs. 204

F. Description of Commercially Important Fisheries 220

G. Resources of the Louisiana Coastal Zone and Adjacent Waters. 232
1. Land Use in the Coastal Zone. 232
2. Recreation Resources. 246
3. Commercial Fisheries of Louisiana 284

Table of contents (cont')

	Page
4. Ports and Shipping.	301
5. Economy in the Coastal Zone.	303
6. Oil and Gas Resources.	321
H. Existing Environmental Quality in Nearshore and Coastal Zone.	322
1. Water Quality	322
2. Air Quality	322
3. Noise	323
4. Dredging.	323
BIBLIOGRAPHY.	324
III. OFFSHORE OIL AND GAS OPERATIONS	336
A. A Description of Oil and Gas Operations Including a Timetable for this Proposal	336
1. Geophysical Exploration	336
2. Exploratory Drilling.	341
3. Development Drilling, Production and Workover . .	352
4. Transportation of Produced Oil and Gas.	371
5. Termination of Offshore Oil and Gas Operations. .	379
6. Timetable for Development of Tracts Leased at Sale.	380
B. General Environmental Impacts of Offshore Oil and Gas Operations.	381
1. Impact Resulting from Day-to-Day Operations Which are Unavoidable Under Existing Operating Practices, Regulations, Economics and Technology.	381
2. Impacts Resulting from Accidents.	389
3. Impacts Which can be Minimized or Avoided by Regulations and Safe Operating Practices.	420
4. Summary of Impacts.	420

TABLE OF CONTENTS

VOLUME II

Page

IV. ENVIRONMENTAL IMPACT OF THE PROPOSED SALE 1

A. Impact on the Living Component of the Environment: An Introduction. 1

B. Impact on the Open Gulf 7
1. Pelagic Marine Life 7
2. Benthic Marine Life 20

C. Impact on the Communities of the Coastal Zone 25
1. Bays and Estuaries. 28
2. Marshes 37
3. Beaches 39
4. Artificial and Hard Substrate Communities 41
5. Impact on Bird Life 44

D. Impact on Commercial Fisheries. 51
1. Removal of Sea Floor From Use by Trawlers 51
2. Creation of Obstructions on the Sea Floor that Cause Damage to Trawling Nets 54
3. Loss of Catch Due to Contamination. 58
4. Impact on Commercial Fish Species 58

E. Impact on Air and Water Quality 65
1. Impact on Air Quality 65
2. Impact on Water Quality 68

F. Conflict with Ship Traffic and Navigation 71

G. Conflict with Military Uses of the Continental Shelf. . 72

H. Impact on Recreational, Historical, and Archeological, Aesthetic and Conservation Resources. 73
1. Beach and Shoreline Recreation. 73
2. Aesthetic and Scenic Values 75
3. Historical or Archeological Sites and Objects . . . 77
4. Conservation Resources. 78
5. Sport Fishing 79
6. Impact on Endangered or Threatened Wildlife 81

		Page
I.	Secondary Impacts	84
	1. Induced Industrialization in the Coastal Zone	84
	2. Economic Effects	87
J.	Potential Impact of Royalty Bidding	102
K.	A Matrix Analysis of Some Possible Adverse Impacts on the Environment and Related Uses	104
	1. Purpose	104
	2. Significant Resource Factors	104
	3. Impact Producing Factors	105
	4. Analytic Procedures	106
L.	Recapitulation of the Matrices	116
	1. Refuges/Management Areas	116
	2. Unique and Highly Productive Areas	116
	3. Biota Seaward of Estuary/Nursery Areas	116
	4. Beaches	117
	5. Shipping	117
	6. Outdoor Recreation	118
	7. Commercial Fishing	118
	8. Sport Fishing	119
	9. Ordnance Disposal Areas	120
M.	Summary Risk Analysis	121
	1. High Hazard Potential to the Environment	121
	2. Moderate Hazard Potential to the Environment	123
	3. Minimal Hazard Potential to the Environment	125
	BIBLIOGRAPHY	127
V.	MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION	134
A.	Oil Spills	136
	1. Regulations	136
	2. Inspection	140
	3. Enforcement	144
	4. Contingency Action	150
B.	Structures	156
C.	Pipelines	160
D.	Other Mitigatory Measures	166

Table of contents (cont')

			Page
		1. Special Stipulations.	166
		2. Notices to Lessees and Operators.	167
		3. Departures.	168
		4. Research on Advanced Technology	168
		5. Geophysical Information	169
		6. Conservation Practices.	172
		7. Other Requirements.	174
VI.	UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS		176
	A.	Effect on Marine Organisms.	176
	B.	Wetlands and Beaches.	180
	C.	Deterioration of Air Quality.	180
	D.	Deterioration of Water Quality.	181
	E.	Interference with Commercial Fishing Operations . . .	182
	F.	Interference with Ship Navigation	183
	G.	Damage to Historical and Archeological Sites, Structures, and Objects	183
	H.	Interference with Recreational Activites.	184
	I.	Degradation of Aesthetic Values	184
	J.	Conflict with Other Uses of the Land.	185
	K.	Summary	186
VII.	RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY		187
VIII.	IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES. .		190
	A.	Mineral Resources	190

	Page
I. Secondary Impacts	84
1. Induced Industrialization in the Coastal Zone . .	84
2. Economic Effects.	87
J. Potential Impact of Royalty Bidding	102
K. A Matrix Analysis of Some Possible Adverse Impacts on the Environment and Related Uses	104
1. Purpose	104
2. Significant Resource Factors.	104
3. Impact Producing Factors.	105
4. Analytic Procedures	106
L. Recapitulation of the Matrices.	116
1. Refuges/Management Areas.	116
2. Unique and Highly Productive Areas.	116
3. Biota Seaward of Estuary/Nursery Areas.	116
4. Beaches	117
5. Shipping.	117
6. Outdoor Recreation.	118
7. Commercial Fishing.	118
8. Sport Fishing	119
9. Ordnance Disposal Areas	120
M. Summary Risk Analysis	121
1. High Hazard Potential to the Environment.	121
2. Moderate Hazard Potential to the Environment. . .	123
3. Minimal Hazard Potential to the Environment . . .	125
BIBLIOGRAPHY	127
V. MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION . . .	134
A. Oil Spills.	136
1. Regulations	136
2. Inspection.	140
3. Enforcement	144
4. Contingency Action.	150
B. Structures.	156
C. Pipelines	160
D. Other Mitigatory Measures	166

Table of contents (cont')

Page

1. Special Stipulations. 166
2. Notices to Lessees and Operators. 167
3. Departures. 168
4. Research on Advanced Technology 168
5. Geophysical Information 169
6. Conservation Practices. 172
7. Other Requirements. 174

VI. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS 176

A. Effect on Marine Organisms. 176

B. Wetlands and Beaches. 180

C. Deterioration of Air Quality. 180

D. Deterioration of Water Quality. 181

E. Interference with Commercial Fishing Operations . . . 182

F. Interference with Ship Navigation 183

G. Damage to Historical and Archeological Sites, Structures, and Objects 183

H. Interference with Recreational Activites. 184

I. Degradation of Aesthetic Values 184

J. Conflict with Other Uses of the Land. 185

K. Summary 186

VII. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY 187

VIII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES. . 190

A. Mineral Resources 190

Table of contents (cont')

Page

B. Land Resources. 190

C. Fish and Wildlife Resources 190

IX. ALTERNATIVES TO THE PROPOSED ACTION 191

A. Hold the Sale in Modified Form. 191
1. Details of Tract Selection Process for Proposed Louisiana Sale. 191
2. Sale Modification Alternatives. 196

B. Withdraw the Sale 201
1. Energy Conservation 206
2. Conventional Oil and Gas Supplies 206
3. Coal. 209
4. Synthetic Sources of Oil and Gas. 212
5. Hydroelectric Power 220
6. Nuclear Power 224
7. Energy Imports. 228
8. Other Energy Sources. 233
9. Combination of Alternatives 238

C. Delay Sale. 242
1. Until New Technology is Available to Provide Increased Environmental Protection. 242
2. Pending Completion of Studies Concerning the Potential Environmental Impacts of Offshore Minerals Development in General and Oil Spills Specifically. 242
3. Pending Development of Land Use and Growth Plans Offshore. 244
4. Pending Completed Implementation of Recommendations Made in Reports on OCS Operating Orders and Regulations and a Review of Regulations and Amendments as Necessary 244

D. Government Exploratory Drilling Before Leasing. . . . 248

X. CONSULTATION AND COORDINATION WITH OTHERS 252
A. Federal 252
B. State 252
C. Public. 253

ATTACHMENTS

Attachment A -	OCS Operating Orders Nos. 1 through 12 Gulf of Mexico
Attachment B -	Proposed Schedule - Provisional OCS Leasing
Attachment C -	Description of Blocks by Water Depth, Distance from Shore, Acreage
Attachment D -	Report of the Work Group on OCS Safety and Pollution Control, U.S. Geological Survey
Attachment E -	Geological Time Chart
Attachment F -	Windroses Portraying Monthly Wind Patterns over the Gulf of Mexico
Attachment G -	Population, Employment, Personal Income and Earnings by Industry, Historical and Projected
Attachment H -	Matrix Appendix
Attachment I -	Geological Survey, OCS Oil and Gas Operations Lease Management Program
Attachment J -	Equipment Available for Emergency Oil Spill Control and Clean-up in the Gulf of Mexico
Attachment K -	Sample OCS Lease Form
Attachment L -	Summary of U.S. Coast Guard Regulations
Attachment M -	<u>Federal Register</u> Notice Related to the Two-Tier Nomination System
Attachment N -	Comment of Solicitor's Office, Department of the Interior
Attachment O -	Common Names and Scientific Names for Marine Benthic Animals
Attachment P -	Description and Charter of OCS Research Advisory Board
Plat -	Depiction of Blocks Proposed for Leasing

Note:

This draft environmental statement has been prepared pursuant to section 102(2)(C) of the National Environmental Policy Act of 1969.

The regulations to which reference is made throughout this environmental statement are 30 CFR Part 250 and 43 CFR 3300, and Geological Survey OCS Orders Nos. 1 through 12 - Gulf of Mexico. The OCS Orders for the Gulf of Mexico have been appended to this statement (see Attachment A). Although too bulky to append here, the CFR's cited may be obtained from the United States Department of the Interior.

I. DESCRIPTION OF PROPOSAL

A. Location and Reserves

The sale under consideration includes 295 tracts offshore Louisiana. 1/ These tracts if leased, would add more than 1.4 million acres, an increase of about 27.0% to the current total of 5,200,000 acres (as of February, 1974), under Federal lease in the Gulf of Mexico. Twenty-three tracts or 192,044 acres are drainage and development tracts, the remaining 264 tracts are wildcat. The proposed lease sale would be made under Section 8 of the Outer Continental Shelf Lands Act (76 Stat. 462; 43 U.S.C. Sec. 1337) and regulations issued under that statute.

Section 8(a) of the OCS Lands Act provides the Secretary of the Interior with the discretionary authority to issue leases on the basis of a cash bonus with a fixed royalty of not less than 12½ percent or on the basis of royalty not less than 12½ percent with a cash bonus fixed by the Secretary. With the exception of 10 tracts (Tract #25, 30, 42, 80, 103, 145, 193, 208, 237 and 290) all other tracts in this proposed sale will be offered on the basis of cash bonus bidding with a fixed royalty of 16-2/3 percent. The ten designated tracts will be offered on the basis of royalty bidding with a fixed cash bonus.

1/ The tracts are summarized by water depth, distance from shore, and expected type of production in Attachment C. Also see leasing map attached to inside back cover of Volume 2.

The estimated reserves to be developed on this sale are 300-700 million barrels of oil and 5-11 trillion cubic feet of gas. This would require 700-900 wells from 100-200 platforms and require 1300 miles of pipeline. It is estimated that the proposed leases may produce 70,000-125,000 barrels of oil per day and 1.0-2.2 billion cubic feet of gas per day after development and production stabilizes.

In 1972, about 12% of the United States production of oil and condensate, and more than 13% of the gas was from the OCS.

B. Relationship of This Proposed Action to Existing and Prospective Offshore Oil and Gas Development in the Gulf of Mexico

This proposed action must be viewed as one part of a continuing activity that has been underway since the 1940's and that will continue indefinitely, with or without this proposed lease sale, on into the future. Although primary emphasis concerning the description of the proposal and its potential environmental effects has been placed on this particular sale in isolation from all previous activities of the same nature, it should also be put into a perspective of an on-going offshore oil and gas development process. As of January 11, 1974 there have been 24 OCS oil and gas lease sales on submerged lands in Federal areas of the Gulf of Mexico and 4 offshore the Pacific Coast.1/

Table 1. Total Acreage Leased From the Inception of OCS Leasing Activities Through January 11, 1974

Area	Acreage
Louisiana	6,578,467.78
Texas	2,226,929.11
Florida	617,876.89
Pacific (Cali., Wash., Ore.)	1,258,974.38
Total	10,682,248.16

Table 2. Acreage Currently Under Lease as Of January 11, 1974

Area	Acreage
Louisiana	4,115,704.19
Texas	706,227.41
Pacific Coast	351,877.48
Eastern Gulf (Miss., Ala., Fla.)	485,396.87
Total	5,659,205.95

1/ There also have been five OCS sulphur and salt sales in the Gulf of Mexico.

The total acreage expected to be made available for leasing under the five-year lease schedule of OCS sales is approximately 15 million.

The relationship of this proposed sale to other offshore oil and gas development activities in the Gulf of Mexico indicates that additional increments of transportation and storage facilities, platform and pipeline construction activities required if this sale proceeds, for example, will be added to a whole network of existing facilities and activities. As of this writing there is a total of 2,000 offshore platforms on the OCS in the Gulf of Mexico and 5 offshore California. There is a total of 67 mobile drilling rigs available in the Gulf of Mexico of which 65 are working and there is one mobile rig working offshore California. The Bureau of Land Management as of February 20, 1974 had issued 340 pipeline right-of-way permits resulting in 4,257 miles of pipelines on the OCS. The Geological Survey has issued a total of 830 pipeline permits on the OCS resulting in 2,361 miles of offshore pipelines.

As production declines in existing areas, much of the equipment, transportation facilities, pipelines, platforms, etc., not to mention the personnel and technological expertise presently available, can be used for new areas of activity. As existing areas of production decline the pipelines in place for that system can be used for new production areas, adjacent, or further from shore, reducing the quantity of pipelines necessary to transport production from new areas to shore. This latter

event has already been exercised in some areas of the Gulf of Mexico. Likewise a reduction in quantity of onshore facilities such as treatment plants, refineries, storage facilities, etc., is made possible by utilizing existing facilities, equipment and technology. Nevertheless, in this proposed sale some new pipelines, drill rigs, platforms and expansion of existing onshore facilities and perhaps construction of new ones where necessary, will be required although the quantities involved will be less than they would be without utilization wherever possible of existing facilities.

Cumulative effects on the environment from OCS leasing will result as more and more areas are made available for an expanded offshore mineral development program. An increased level of potential conflict with navigational hazard will result from the accumulation of additional offshore structures associated with OCS leasing. This will have its greatest effect on commercial shipping and fishing activities. The effect of increasing the numbers and lengths of pipelines to shore will also have a cumulative impact on the onshore and offshore environment. The effect is expected to have its greatest impact in those nearshore and onshore areas which feature estuaries, marsh, and wetlands environments. The biota in the path of a pipeline will undergo disruption, loss of habitat, and will suffer physiological stress, injury or death. The overall, relative significance of this effect in most areas is considered low because of the small areas involved and the short duration of the activity. In eastern and central portions of coastal Louisiana, the cumulative effect of pipelines has been more

severe, due to the necessity of using large, permanent flotation canals through the unconsolidated marsh substrate for pipeline laying operations. In addition to pipelines, additional increments of transportation, storage, refinery, treatment and other facilities and activities associated with oil and gas production on the OCS will have an overall, cumulative effect on the coastal environment and local and regional economics. The initial effect on biota will be one of disruption and destruction in the construction areas. The effect on air and water quality is unknown, at this time. The overall significance of these effects on a cumulative basis are unknown, but are considered adverse.

There will be a cumulative effect resulting from solid and liquid waste disposal associated with OCS development and any oil polluting events should they occur. The effect will be physiological stress and death for oiled plants and animals and possible contamination of marine food sources for man. The scope, duration, location and overall significant effects of an oil spill on a cumulative basis are unknown. However, the area of greatest potential for receiving lethal and sub-lethal adverse effects on a cumulative basis are embayments and semi-enclosed waters where many species undergo early development and are more vulnerable to toxic compounds. The probability of a massive oil spill resulting from operations on the Outer Continental Shelf impacting upon areas such as these is considered to be low because of the distances involved and the fact that in the history of OCS leasing, no

oil spill resulting from an OCS lease area has ever penetrated semi-enclosed embayments, estuaries, or wetlands. By far the most likely single source of a massive spill in these sensitive areas is from tankers. In the past, tankering of OCS production has not been necessary principally due to its proximity to refineries.

C. Background of Proposal

The sale under consideration is the third sale listed in the proposed five-year schedule released in July 1973. The first two of these sales have been held. This schedule was issued in response to President Nixon's Energy Message of April 18, 1973, which directed the Secretary of the Interior to take steps to triple the annual acreage leased on the OCS by 1979.

This particular sale is the first in which bidding for leases on a royalty basis will be conducted on a test basis. The OCS Lands Act provides the Secretary of the Interior with discretionary authority to issue leases on the OCS to the highest bidder either on a cash bonus basis with a fixed royalty or on a royalty bidding basis with a fixed cash bonus. The purpose of the test is to determine what the effect of royalty bidding for OCS leases will have on Federal revenues, competition and the rate of production on individual leases.

The recent Middle East oil embargo, the uncertainty of foreign energy imports, and the steep rise in costs of importing energy with the corresponding implications for the U.S. balance of payments, have all underlined the need to develop domestic energy sources. On November 7, 1973, the President, in an address to the Nation, stressed the need for energy independence with a proposal for self-sufficiency by 1980 entitled Project Independence.

Steps to alleviate the energy shortage taken by the Federal Government in the last few months include establishment of a major conservation program to reduce use of energy by Federal agencies, creation of a

Federal Energy Office to serve as a focal point for energy actions taken by the Government, institution of a fuel allocation program, and passage by Congress of laws reducing the national highway speed limits to no more than 55 miles per hour and putting the Nation on year-round daylight savings time starting on January 6, 1974.

On January 23, 1974, President Nixon again addressed the Nation on proposals to deal with the energy crisis. He outlined an extensive legislative program which he urged Congress to act on in 1974. Included were measures both to meet the short-term emergency and to achieve long-term self-sufficiency in energy. Among these legislative proposals were:

establishment of a Federal Energy Administration

market pricing of new natural gas

mandatory reporting of information by private industry

Federal licensing of deepwater port facilities offshore

elimination of depletion allowances for foreign oil and gas production

modernization of the Mineral Leasing Act

facilitation of the site selection, approval, and licensing process for energy facilities.

In addition to his legislative program, the President announced a number of executive actions related to achieving self-sufficiency. One of these concerned OCS development:

"I am directing the Secretary of the Interior to increase the acreage leased on the OCS to 10 million acres beginning in 1975, more than tripling what had originally been planned. In later years, the amount of acreage to be leased will be

based on market needs and on industry's performance record in exploring and developing leases. In contracting for leases, the Secretary of the Interior is also to ensure that the proper competitive bidding procedures are followed and that environmental safeguards are observed. He will, in addition, set up an interagency program for monitoring the environmental aspects of the new leasing program. There will be no decision on leasing on the OCS in the Atlantic and in the Gulf of Alaska until the Council on Environmental Quality completes its current environmental study of those areas."

To implement this accelerated leasing program, the Department of the Interior has developed a new two-tier nomination system to help ensure that the most promising offshore areas be made available for development first, if environmentally acceptable. 1/ Under this system, industry will first rank the regions that they think are most favorable. The public will be invited to identify environmental conditions and problems in these regions. The Interior Department will use the industry and environmental rankings of regions, along with its own evaluations of resource potential and need to protect environmental values, to select the most promising regions for early development. Subsequently, within designated sale areas, industry will nominate individual tracts as is currently being done. The two-tier system

1/ A notice related to the two-tier nomination system appeared in the Federal Register on February 20, 1974, and is included as Attachment M.

will help ensure that our scarce oil exploration and development resources can be employed on the most promising tracts, and that major areas of environmental concern will not be touched.

To protect the environment while significantly expanding the leasing program, the Department is planning to begin environmental analysis of promising areas even before industry nominations of regions have been received. Later, as region nominations are received, study will begin on those areas not already being analyzed. In addition, the program will provide for monitoring environmental effects of exploration and development. Baseline studies will provide a profile of the regional environment prior to the beginning of any exploratory activity. Then, any subsequent ecological disruptions can be detected and necessary remedial steps taken.

To increase sale competition, the Department is examining various options, including legislation, aimed at more rapid disclosure of geologic and geophysical data on leased tracts. This disclosure will increase available information about general regions prior to subsequent sales within the same region.

The acceleration of OCS leasing and other measures to increase domestic energy development reflect declining availability of oil and gas. Reports submitted by interstate pipeline companies to the Federal Power Commission show a deteriorating gas supply situation and declining proven gas reserves of these companies. These declines are due to the fact that new additions to reserves have not been sufficient to offset production volumes. Interstate pipelines imposed curtailments of firm requirements totaling 1.39 trillion

cubic feet during the period September 1972 through August 1973. These curtailments amounted to 7.32 percent of the firm requirements of those interstate pipeline companies reporting deficiencies. For the period September 1973 through August 1974, curtailments of firm service are projected to total 2 trillion cubic feet, or about 10.42 percent of the firm requirements reported by 36 major pipelines (Class A and B) and one Class C pipeline. 1/

1/ Federal Power Commission, News Release No. 20019, Washington, D.C., January 31, 1974.

D. Proposed Five-Year Schedule - Provisional OCS Leasing

The proposed schedule was issued in July 1973. 1/ In the development of the schedule, the Department considered its three leasing objectives: orderly resource development, protection of the environment, and receipt of fair market value. These objectives constitute overall policy parameters for the OCS program. An analysis was made in broad terms of when, where, and how much oil and gas acreage to offer for lease. This was done through a review of the national energy situation and the identification of future supply-demand imbalances. Deficits were identified by matching projections of future non-OCS supplies of oil and gas and future OCS production from existing leases with future projected demand. Demand forecasts were made on a regional basis, using the regions of the Future Requirements Committee for gas and the Petroleum Administration for Defense districts for oil. One of the tools available for analysis of the effect of various leasing options on regional supply is a computer model for natural gas. This model allocates future natural gas supplies on the basis of least cost and identifies national and regional supply gaps. It gives an indication of what regions OCS natural gas production serves, the effect of regional price changes on the allocation system, and where large deficits will exist. A

1/ See Attachment B.

similar model is being developed for oil. New OCS sales were then proposed in line with helping to meet the deficits. Different alternative schedules were tested with respect to their impact on demand.

These different options were also reviewed from the perspective of receipt of fair market value. The size and frequency of sales can induce or inhibit a competitive market which in turn affects the Government's receipt of fair market value.

Under the proposed five-year schedule, an environmental impact statement based upon detailed analysis of all appropriate data will be prepared for each proposed OCS oil and gas lease sale included in the five-year schedule.

No sales are scheduled on the Atlantic OCS or in the Gulf of Alaska. However, studies of the environment, economics, natural resources, and other regional factors of these areas are being and will be carefully analyzed. An in-house data reconnaissance study on the Mid-Atlantic area has been completed. 1/

The Bureau of Land Management has awarded contracts to independent research groups for environmental and socio-economic analysis of Alaska, Atlantic, Pacific and Gulf of Mexico areas. The Bureau of

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1/ Library Research Project Mid-Atlantic Outer Continental Shelf (Reconnaissance), Dept. of Interior, Bureau of Land Management, December, 1972.

Land Management is also currently working closely with the Council on Environmental Quality and other Federal agencies to provide, as a result of current contract and in-house studies, the information necessary for the implementation of the President's directive in his April 18, 1973 Energy Message, to assess the environmental impact of oil and gas production on the Atlantic OCS and in the Gulf of Alaska. The proposed schedule has indicated that if CEQ's study of the environmental impact determines that development in these areas can proceed in an environmentally satisfactory manner, lease sales in one or both areas will be added to the proposed schedule at the earliest practicable time.

In January, 1974, the President directed that OCS leasing be accelerated to 10 million acres beginning in 1975. A revised schedule will be issued to reflect this directive.

E. Activity, Environment, and Impact from the Five-Year Schedule in the Gulf of Mexico

1. Proposed Sales

Sales tentatively included in the proposed five-year schedule are shown on Attachment B.

2. Development

Table 3 indicates the intensity of activity that will be required in order to develop the hydrocarbon reserves believed to underline the Gulf of Mexico areas included in the five-year schedule.

3. Environment

The coastal zone of the Gulf of Mexico is richly endowed with estuaries and coastal marshes. Over 200 estuarine systems extend from Florida Bay and the famous Ten Thousand Islands of the Everglades to the Hypersaline Laguna Madre of the Southwest Texas coast. It is estimated that there are about 12.7 million acres of estuary and coastal marsh habitat in the five states bordering the Gulf of Mexico. This 12.7 million acres is about 45% of the total estuary and coastal marsh area in the contiguous 48 states, and about two-thirds is coastal marshes and one-third estuarine water area. It is this area of shallow estuaries and marshes that makes the Gulf of Mexico so productive of fish and wildlife resources. 1/

1/ U. S. Congress, Senate, Report of the Secretary of the Interior to the U. S. Congress, the National Estuarine Pollution Study, 91st Congress, Second Session, March 1970.

Table 3

STATUS OF OCS LEASING AND FIVE-YEAR PROJECTION

	This Proposed Sale	Current Status	Increment: 1/ Five-Year Schedule	1979 Status
a. Acres under lease (million)	1.14 2/	5.2 5/	8.0-10.0	12-14 3/
b. Reserves to be developed:				
- oil (million bbl.)	300-700		7,000-15,000	
- gas (trillion cu. ft.)	5-11		50-100	
c. Remaining reserves:				
- oil (billion bbl.)		4.0		4.0-8.0
- gas (trillion cu. ft.)		32		32-60
d. Wells	700-900	11,714 5/	6,000-15,000	17,000-26,000
e. Platforms	100-200	2,014	800-1,900	2,800-3,900
f. Miles of Pipelines	1,300	7,000 4/	2,000-4,000	9,000-12,000
g. Terminal/Storage Facilities	0-7	74-82	14-32	90-120

1/ All figures are for development over the life of the leases issued during the five-year period.

2/ Estimated that 80% of the acreage proposed for offering in this sale will lease.

3/ This assumes that some leases will have expired or will have been relinquished.

4/ Includes approximately 3,100 miles of common carrier pipeline.

5/ U.S. Geological Survey monthly Engineering Report. February, 1974.

(All data for this table supplied by the U.S. Geological Survey.)

From the shoreline of the barrier islands of the Gulf, waters deepen gradually at a rate of about six feet per mile out to depths of about 300 feet, where the gradient increases more rapidly out to the shelf break or continental slope. In some areas the shelf is more than 100 miles wide. The Gulf coastal area lies, generally, in a zone of transition between tropical and temperate weather patterns. The climate is mild (mean temperature 69° F.) and the area receives considerable precipitation (55 inches annually). Wind flows are complicated, particularly in the cold months, when the normal track of disturbance traveling west to east lies near the coast.

The Gulf of Mexico is defined ecologically as a high energy system in which the naturally generated energy supply is sufficient to maintain a large and diverse population of plant and animal life. The extensive shallow water area of the continental shelf provides a broad expanse of nutrient laden substrate that tends to concentrate commercial species of fish where they can be caught readily.

a. Wildlife

The coastal area in and adjacent to the Gulf of Mexico offers wintering and nesting areas for a large proportion of the waterfowl population of the United States. It is the southern terminal for much of the Central Flyway and both the Mississippi and Atlantic Flyways. Twenty-five national wildlife refuges, including 486,780 acres are located in the area. These are distributed as follows:

	National Wildlife Refuges	Acres
Texas	5	131,333
Louisiana	5	232,476
Florida	15	122,971

In addition, 66,250 acres of wildlife habitat adjacent to the refuges have been closed to hunting by Presidential Proclamation.

Each state, including Louisiana, Alabama, and Mississippi, Florida, and Texas, also operates several wildlife refuges or management areas adjacent to the Gulf of Mexico.

b. Fishery Resources

The rich, nutrient laden estuaries of the Gulf of Mexico produce an abundance of sport and commercial fish. Major species by type of estuarine dependence are: 1/

Sport Fish

Residents While Juveniles and Adults	Residents While Larvae and Juveniles
Crabs, Spotted Seatrout Oysters, Snook	Croaker, Tarpon, Black and Red Drums, Spot, Mullet, Sand Seatrout, Whiting, Shrimp, Flounder, Salt Water Sheepshead, Salt Water Catfish, Bluefish, Ladyfish

Commercial Fish

Residents While Juveniles and Adults	Residents While Larvae and Juveniles
Oysters, Blue Crabs Spotted Seatrout, Stone Crab	Same as above plus Menhaden but not Tarpon

1/ The National Estuarine Pollution Study, op. cit., p. 116.

c. Recreation

The Gulf of Mexico offers a wide variety of outdoor recreation opportunities. The recreational resources of the areas are summarized as follows: 1/

Florida

Florida's total recreation shoreline on the Gulf of Mexico is 1,755 miles including 111 miles of public recreation areas and 771 miles of beach. Approximately half of the entire shoreline (840 miles) consists of mangrove swamps or marsh. All water oriented recreation activities are feasible in the area, but swimming and fishing are the most popular.

Alabama

Total recreation shoreline in Alabama is 204 miles including 115 miles of beach and 89 miles of marsh shore and only 3 miles of public recreation areas. Swimming, fishing, sailing and boating are suited to the areas and are the most popular recreation activities.

Mississippi

Mississippi's total recreation shoreline is 203 miles including 69 miles of marsh shore and 134 miles of beach. The Mississippi mainland shoreline lies some miles behind a widely broken chain of offshore

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1/ All statistics pertaining to outdoor recreation were taken from, Shoreline Recreation Resources of the United States, Outdoor Recreation Resources Review Commission, Report No. 4, 1962.

islands (Petit Bois, Horn, Ship and Cat Islands), which protect the shore from the open Gulf. The area is best suited for such recreation activities as swimming, fishing, sailing and boating.

Louisiana

Louisiana's total recreation shoreline (including Lake Pontchartrain) is 1,076 miles including 819 miles of marsh shore and 257 miles of beach. Fishing, hunting, wildlife study, boating, and related activities are best suited to the area. Swimming is feasible but the nature of most beaches and offshore bottom make them less than attractive.

Texas

Area available for recreation in the Texas coastal zone is 23.3 square miles, or 0.2% of the total land area in the coastal zone. 1/ This recreation area includes 343 linear miles of beach and 359 miles of marsh shore. The shorelines are probably as little developed as any beach areas in the United States. All water oriented types of recreation activity are feasible on the Texas shore.

National Park Service Units 2/

National Park Service units in the Gulf of Mexico area are:

Padre Island National Seashore
Gulf Islands National Seashore

1/ Flawn, P. T. and B. Fisher, 1970. Land-use Pattern in the Texas Coastal Zone. In: The coastal resources management programs of Texas, appendices. Ed. by J. T. Goodwin and J. C. Mosely, Coastal Resources Management Program, Office of the Governor, Austin.

2/ Current data, National Park Service.

DeSoto National Monument
Everglades National Park
Fort Jefferson National Monument

Potential new areas are:

Suwanee Wild and Scenic River
Jean Lafitte National Cultural Park
Wakulla River National Monument or Wild and Scenic River

In addition to Feceral areas, the following National Landmarks are located in the Gulf of Mexico area:

Fort Morgan National Historic Landmark
Fort San Marcos De Apalche National Historic Landmark
Safety Harbor Site National Historic Landmark
Ligunmvitae Key Natural Landmark

4. Resource Use and Commercial Activity Related to the OCS in the Gulf of Mexico

The following major activities and resource uses occur on the OCS or are related to the OCS of the Gulf of Mexico.

a. Mineral Industry

The petroleum refining industry and the related extraction industries of Louisiana and Texas have a growth rate several times greater than the national rate for industries of this type. In 1972, Gulf of Mexico OCS operations produced more than 412 million barrels of oil and condensate valued at $1.46 billion, and about 3.0 trillion cubic feet of gas and over 1.7 billion gallons of gas liquids valued at over $752 million. Total sulphur production onthe OCS was about 1.2 million tons valued at $22.3 million. In addition, 358,782 tons of salt were produced in 1972 with a value of $64,581. 1/

1/ "Outer Continental Shelf Statistics, Calendar Year 1972", published June 1973 by U. S. Geological Survey, Conservation Division.

b. Commercial Fishing

The Gulf of Mexico is one of the most productive fishing areas in the United States. In 1972, the commercial fishing catch was 1.585 billion pounds valued at $223.4 million ($0.141/lb. paid to fisherman). This catch was 33.6% of the volume and 31.8% of the value of the total United States commercial fisheries catch in 1972. 1/

c. Sport Fishing

In 1970, an estimated 2.4 million fishermen, 12 years and older, spent 25.7 million man-days of fishing in the Gulf of Mexico. Approximately 53% of this sport fishing was in the ocean or from beaches and 47% was in estuaries. 2/ No projections are available for 1973, but the 1970 level is expected to increase.

d. Recreation

In 1970, recreationists participated in 215 million recreation activity occasions 3/ in the Gulf of Mexico area; by 1975 it is expected that recreationists will participate in approximately

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1/ U.S. Dept. of Commerce, "Fisheries of the United States, 1972" NOAA, NMFS-5900.

2/ Projected from 1965 National Survey of Fishing and Hunting and 1965 Salt Water Angling Survey; U.S. Fish and Wildlife Service, and the 1970 Salt Water Angling Survey, National Marine Fisheries Service.

3/ A recreation activity occasion is the participating in a single activity by a single individual.

250 million recreation activity occasions in the area. 1/ Recreation activities in the Gulf area are, of course, largely water-oriented. Water-oriented recreation is the most popular form of outdoor recreation in the United States. The warm climate of the Gulf of Mexico makes this area very attractive to recreationists in, and beyond, the region.

Last year's and estimated future visits to National Park Service units in the Gulf of Mexico are as follows:

	Visits in 1972 2/	Estimated Visits 1976
Padre Island	883,800	1,165,900
Gulf Islands	606,900 3/	2,052,600
De Soto N. Mon.	139,200	161,600
Everglades	1,773,300	1,428,200
Ft. Jefferson	15,700	20,900
Chalmette	364,000	4/

1/ The above estimates for recreation use are based on data and procedures contained in A New Perspective on Recreational Use of the Ocean, National Planning Association, Winslaw and Bigler. The above estimates are included for the purpose of presenting order of magnitude data and could be subject to considerable adjustment.

2/ Public Use of the National Parks, Dec. 1972, National Park Service, Department of the Interior.

3/ From its opening through 7/73.

4/ No projections available at this time.

e. Shipping

The Gulf of Mexico is subject to heavy shipping traffic. The seventeen major ports and harbors from Tampa to Corpus Christi handled about 517 million tons of freight and 235,000 vessel calls during 1972. These totals include almost 218 million tons of crude oil and petroleum products and over 75,000 tanker and tank barge calls. 1/

f. Military Use

Some areas of the Gulf of Mexico are designated Defense Warning Areas by branches of the U. S. Armed Forces and are to be used for military purposes. A possible constraint on the extent of future offshore oil and gas leasing involved conflicts in some areas between mineral development and high priority uses of the Department of Defense. Some adjustments in Defense Warning Areas on the OCS and/or development of adequate special oil and gas lease stipulations, where appropriate, will need to be made before mineral leasing in such areas can proceed. At this time, there are no tracts in this proposed sale the development of which would cause interference with activities in the area.

g. Research and Education

Besides applied research in petroleum geology, ocean engineering, commercial fishing, fish farming, and other fields, a

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1/ Waterborne Commerce of the United States - Calendar Year 1972 Part 2 Waterways and Harbors Gulf Coast, Mississippi River System and Antilles - Department of the Army, Corps of Engineers.

number of Gulf states colleges and universities are involved in basic research in the marine sciences. The shoreline and open waters of the Gulf of Mexico serve as an important outdoor laboratory. Table 4 lists colleges and universities, and degrees offered, that carry out part or all of their field education and research in the Gulf.

An example of this emphasis on field research in the Gulf involves the plans of the University of Texas Medical Center to establish Flower Garden Ocean Research Center. 1/ If the university's plans are implemented, the facility would be located in 80 feet of water about 120 nautical miles SSE of Galveston, Texas. Facilities proposed by the university consist of an offshore platform with laboratory modules, living quarters, power generators, and support facilities. On the coral reef below, there would be placed a Tektite-type undersea habitat.

h. Land and Water Conservation Fund

"The Land and Water Conservation Fund was established in P.L. 88-578, as amended, to help plan for, acquire, and develop outdoor recreation resources for the benefit and enjoyment of all Americans.

Oil and gas, sulfur, and salt royalties credited to the U.S. Treasury from Outer Continental Shelf operations, together with lease rentals and bonuses from OCS lease sales are, in turn, earmarked to the Land and Water Conservation Fund in amounts authorized by the Congress."

1/ Marine Biomedical Institute, University of Texas, 1971. The Texas Tektite Project: Flower Garden Ocean Research Center, Gulf of Mexico. Misc. Brochure, University of Texas Medical Branch, Galveston. 21 pp.

TABLE 4 A PARTIAL LIST OF COLLEGES, UNIVERSITIES AND RESEARCH INSTITUTES UTILIZING THE GULF OF MEXICO FOR RESEARCH AND EDUCATION

Institution	Location	Degree Offered/Research Activity
Univ. of Alabama	Bayou La Batre	Undergrad courses; research
Fla. Institute of Technology	Melbourne	B.S., M.S. in Oceanography
Fla. State University	Tallahassee	M.S., Ph.D. in Marine Biology, Oceanography Ph.D. in Geophysical Fluid Dynamics
Univ. of Florida	Gainseville	M.A., M.S., Ph.D. in main departments with emphasis in Marine Science
Rosenstiel School of Marine and Atmospheric Science--Univ. of Miami	Miami	M.S., Ph.D. in Marine Biology Science, Marine Geology and Geophysics, Physical Oceanography, Chemical Oceanography, and Atmospheric Sciences
Nova University Oceanographic Laboratory	Fort Lauderdale	Ph.D. in Physical, Chemical Oceanography, Marine Biology, Physics (marine emphasis)
Univ. of South Florida Marine Science Institute	St. Petersburg	M.S. in Marine Science
Univ. of West Florida	Pensacola	M.S. Biology--Estuarine, Marine Studies
Louisiana State University	Baton Rouge	M.S., Ph.D. in Marine Sciences
Gulf Coast Research Laboratory	Ocean Springs, Miss.	Affiliated with 29 Gulf States Colleges and Universities; M.S., Ph.D. in Biological Sciences (marine emphasis)
Institute of Engineering Tech. Miss. State University	State College	Bach. of Engineering Tech. (marine emphasis)
University of Southern Miss.	Hattiesburg	M.A., M.S. in Biology, Geology
Gulf Univ. Research Corp.	College Station, Tex.	Consortium of 21 universities and research institutes of Gulf States; basic and applied research in all areas of marine science.
Univ. of Houston	Houston, Tex.	M.S. in Biology, Geology, Ph.D. in Biology (marine emphasis) J.D. with emphasis in marine law
Lamar State College of Tech.	Beaumont	B.S. in Oceanographic Technology
Marine Biomedical Institute	Galveston	Doctoral and Postdoctoral training in marine biomedical sciences
Rice University	Houston	M.A., Ph.D. in Geology, Geophysics, Geochemistry
Texas A & M University	College Station	M.S., Ph.D. in Oceanography, Zoology, Botany, Microbiology, Biology (marine emphasis) M.S. in Marine Resource Management
Texas A & M University Marine Biology Laboratory	Galveston	Basic and applied research in all phases of marine biology
Texas Christian Univ.	Fort Worth	M.S. in Biology, Environmental Science, Geology (marine emphasis)
Texas Maritime Academy Texas A & M University	Galveston	B.S. in Marine Engineering, Marine Transportation
Univ. of Texas at Arlington	Arlington	M.A. in Biology, Chemistry, Physics, M.S. in Geology (all with marine emphasis)
Univ. of Texas	Austin	M.A., Ph.D. in Botany, Chemistry, Geology, Microbiology, Physics, Zoology, Engineering, (marine emphasis)
Univ. of Texas Medical Branch at Galveston	Galveston	Teaching and research in marine biomedical Sciences
Univ. of Texas Marine Institute	Port Aransas	Research in marine science; Seaside facility to augment curricula at Arlington, Austin campuses
University of Puerto Rico	Mayaguez	M.S. in Marine Science
Univ. of West Florida	Pensacola	Ph. D. in Marine Biology

Fiscal Year	Authorized Fund Level	Funds From OCS	Percent From OCS
1969	$200 million	$126.9 million	63
1970	$200 million	$108.1 million	54
1971	$300 million	$210.1 million	70
1972	$300 million	$223.7 million	75
1973	$300 million	$223.9 million	75

Revenue funding also comes from other sources such as motorboat fuel taxes and the sale of surplus Federal real property.

Grants-in-aid under the Fund program can be made only to the states, their cities and countries, and legal political subdivisions. The Federal money pays half the cost of statewide planning projects, land acquisition and development of facilities for public outdoor recreation. Appropriations to the Fund also pay land acquisition costs for authorized areas being added to the national system of parks, forests, wildlife refuges, wild and scenic rivers, and scenic and recreation trails.

5. Possible Environmental Impacts from OCS Oil and Gas Development Resulting from Implementation of the Five-Year Lease Schedule

The environmental impact which would result from implementation of the five-year lease schedule can be estimated with fair accuracy only after specific factors related to each sale are known. For example, at least the following information is needed: (a) location of tracts in relation to resources, shipping lanes, recreation areas, refuges, etc., (b) type of expected production, e.g., oil or gas, (c) geologic formations, (d) water depths, (e) expected terminal points for pipelines, and (f) expected size and location of required new storage facilities.

In general, it can be assumed that future impacts of OCS oil and gas lease sales, both favorable and unfavorable, will be greater on the environment, on other industries, and on communities in areas where no previous OCS oil and gas leasing has been undertaken. This is so because new pipelines and storage facilities must be built, relationships must be developed between existing industries, (i.e., fishing and the oil and gas industry), and new labor forces and new payrolls will be introduced to the area. Conversely, incremental impacts, both positive and negative, will be less offshore Louisiana and Texas where offshore and nearby onshore production has been in existence for many years.

The general impacts expected to result from the implementation of the five-year schedule are expected to be similar to those described in this statement for the proposed Texas OCS lease sale #34.

F. Tract Selection

Having determined through development of the tentative five-year schedule, the timing, size, and location of a specific lease sale, it must be determined which tracts should be offered in the sale. The first step leading toward the selection of tracts is that reports (43 CFR 3300.2) are requested and received from the U.S. Geological Survey - on the general geology and potential mineral resources of the proposed area - and from other interested Federal and state agencies regarding other resources, environmental conditions and the effect of mineral operations on the resources and the total environment. A call for nominations of tracts is then issued by the Department. Industry responds by nominating tracts in which they are interested. With improved seismic, geologic and economic data on the specific sale under consideration, the Department analyzes the past leasing history of tracts under consideration and the nominations themselves and make an initial identification of tracts to be included in the sale.

1. Responsibilities and Procedures

Responsibility for the initial selection of tracts lies with the field offices of the Bureau of Land Management (BLM) and the U.S. Geological Survey (GS) under guidance as to Departmental policy and objectives furnished by the respective Washington offices.

BLM and GS also consider recommendations by the Bureau of Sport Fisheries and Wildlife regarding limitations on permits for exploration and mineral development.

a. BLM-New Orleans Office (NO) is responsible for furnishing the historical and current leasing status of all tracts nominated and their location with respect to fairways, anchorage, and warning areas, and pipelines. BLM-NO makes preliminary selection of tracts based on the following general considerations:

(1) The extent of industry interest as indicated by the number and pattern of nominations.

(2) Past leasing history of the area.

(3) General geological and geophysical data from GS and other sources.

(4) Environmental considerations based on research results presented by the New Orleans Office's Environmental Assessment Team.

(5) Analysis of estimated potential for oil and gas production.

(6) Economic considerations.

(7) A thorough analysis of the resources of the area and an initial evaluation of the potential impact on each individual resource from oil and gas exploration, drilling, and producing operations.

(8) Special considerations such as mix of tracts by water depths and distance from shore.

b. GS-NO is responsible for furnishing technical information including geological, geophysical, engineering, and paleontological

information in determination of tracts to be recommended for selection. GS-NO identifies tracts based on the following criteria: need to initiate leasing in rank wildcat areas from a geologic standpoint; drainage tracts or those in imminent danger of drainage; tracts from which companies have presented data for GS inspection and evaluation demonstrating their necessity and desirability for further development; tracts which are most prospective for production; other tracts susceptible to prompt drilling and development.

c. The Regional Office of BSF&W reviews all the tracts under consideration for the potential effect on fish and wildlife resources and advises BLM-NO accordingly.

d. The Washington Office of BLM and GS furnish guidelines which flow from the Departmental objectives: orderly and timely resource development, protection of the marine environment and receipt of fair market value for leased marine resources. These guidelines include but are not limited to: recommended size of sale; tracts or areas for special consideration; and information relative to Administrative or Departmental policy. The Washington Office also reviews the joint recommendation of tracts submitted by the BLM and GS field offices for conformity with these objectives and guidelines.

2. Purpose of the Tract Selection Process

It is intended that by this initial tract selection process, tracts which have the highest geological potential normally will

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2. <u>Purpose of the Tract Selection Process</u>

It is intended that by this initial tract selection process, tracts which have the highest geological potential normally will

be selected. In response to the Department's call for nominations for the Louisiana general sale, 28 oil companies nominated approximately 5.3 million acres. From this total, a list of 295 tracts comprising over 1,400,000 acres was initially constructed in accordance with the process described above for further detailed environmental analysis. Additional information concerning the initial tract selection process for the proposed Louisiana sale is contained in section VIII.A.

BLM is charged with responsibility for assessment of the impacts on the environment which may occur as a result of leasing operations. The collection of environmental data begins with analysis of preliminary resource reports which are prepared for the overall sale area. The next major stage is the preparation of an environmental report to the GS Manager prior to tract selection. This report is prepared by the Environmental Assessment Team specifically to insure that tracts tentatively selected have been reviewed for potential environmental hazards in the event of their later development.

After completion of tract selection procedures, BLM prepares a draft environmental impact statement, soliciting a wide spectrum of views from Federal, state and local agencies, and the public. This environmental statement evaluates the potential effect of the proposed lease sale on all components of the environment of the entire area during exploration, development and operational phases. Pertinent published and unpublished resource reports and evaluations are reviewed and

portions are included in this statement. In the case of a general sale a public hearing is held. Through these processes, further modification of the list of tracts may result, or special stipulations may be required for the leasing of certain tracts as will be reflected in the final environmental statement.

3. Selection of Royalty Tracts

Of the 295 tracts chosen for this sale, 10 tracts were selected for the royalty bidding test from 10 different trapped hydrocarbon structures. These structures were chosen randomly within the criteria that the structures were to have promising oil and gas potential and that there were to be no tracts under lease on the structure. From the 10 structures, one tract per structure was chosen at random.

G. Contract, Research and Study Programs

1. Introduction

The purpose of this section is to describe studies recently completed, contract studies and research in progress, studies planned for this fiscal year, and a proposed program study plan and monitoring system. All of these study and research efforts are directly related to improvement of OCS management practices, operating procedures and data bases. These studies and research efforts, by identifying problem areas, gaps, weaknesses and proscribing preventive or corrective measures, fulfill an invaluable role for achieving our goal of reducing or eliminating, wherever possible, potential hazards to human life and to the environment.

2. Studies on OCS Practices and Technology

There have been several studies recently completed which identify weaknesses in OCS operating regulations and procedures and recommend remedial measures. The Geological Survey had undertaken on their behalf studies conducted by NASA 1/, the Marine Board of the National Academy of Engineering 2/, and an internal System Laboratory Group of the Water Resources Division of the Geological Survey 3/. An analysis of the results of these studies was completed by a special

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1/ NASA, "Applicability of NASA Contract Quality Management and Failure Mode Effect Analysis Procedures to the USGS Outer Continental Shelf Oil and Gas Lease Management Program", November, 1971.

2/ Marine Board, National Academy of Engineering, "Outer Continental Shelf Resource Development Safety: A Review of Technology and Regulation for the Systematic Minimization of Environmental Intrusion from Petroleum Products", December, 1972.

3/ USGS, "Outer Continental Shelf Lease Management Study", May, 1972.

Work Group of the GS in May, 1973, and a report titled the "Work Group on OCS Safety and Pollution Control" was issued. This report has been appended to Vol. 2 of this environmental statement as Attachment D. Implementation has commenced on all 15 recommendations made by the Work Group in its report.

Specifically, the Geological Survey has initiated actions to implement all of the 15 recommendations as follows:

<u>Recommendation No. 1</u>. Failure Reporting and Corrective Action

<u>Action Taken</u>: OCS Order No. 5 has been revised and now requires operators to submit quarterly failure-analysis reports on subsurface safety devices. The Offshore Operators' Committee is developing procedures for a closed loop failure reporting and corrective action system which will include all critical platform safety components. The output from these systems is computerized and will be analyzed by the safety review committee.

<u>Recommendation No. 2</u>. Accident Investigation and Reporting

<u>Action Taken</u>: The legality of publishing investigation reports of major accidents has been affirmed by the Solicitor's Office of the Department of the Interior. The Regional offices of the Geological Survey are developing accident investigation reporting procedures which are more responsive to cause and effect relationships.

Recommendation No. 3. Information Exchange

Action Taken: A "Safety Alert" system has been initiated. With this system operators are advised of accidents occurring during OCS drilling and producing operations to let the industry know immediately of its own mistakes and malfunctions so that improvements can be made where applicable. It is anticipated that an information dissemination system will be designed during the next fiscal year to provide industry with the results of the failure reporting and corrective action systems, accident investigations, inspections, and other elements of the lease management program.

Recommendation No. 4. Research and Development

Action Taken: A cooperative committee on offshore safety and anti-pollution research has been formed in conjunction with the American Petroleum Institute (API). The purpose of the committee is to determine the research and development efforts being undertaken by industry and Government in this area; determine specific needs for additional efforts; and to contract for research and development in areas where industry response is lacking or unsatisfactory. Current efforts include research on orifice coefficients for velocity controlled subsurface safety valves; research on detection and prevention of sand erosion; and research on removal of oil from water and solids.

Recommendation No. 5. Standards and Specifications

Action Taken: An API-USGS Offshore Safety and Anti-Pollution Committee has been formed. This committee's function is to establish standards and specifications for safety and anti-pollution equipment. The first project undertaken by the committee was a recommended practice for design, installation, and operation of subsurface safety valve systems and specifications for subsurface safety valves. The final copies of these standards have been published. Additional projects undertaken by the committee include: recommended practice for the design, installation, and operation of offshore platform basic surface safety systems; specification for surface safety valves and actuators; and recommended practice for platform piping system design. Draft copies of the standards for platform basic surface safety systems have been made available for review and comment. The final copies of the listed standards will be published later this year (1974). In connection with this, a facility for the testing of subsurface safety valves will be constructed and operated by an independent research institute. A committee is being formed to conduct quality assurance inspections of subsurface safety valve manufacturers. The manufacturers must comply with the quality assurance program as set forth in the specifications for subsurface safety valves in order for those valves to be approved by API.

Recommendation No. 6. System Analysis

Action Taken: System analyses were performed on 13 installations in the Gulf of Mexico under two Geological Survey contracts. These studies are currently being evaluated with the objective of possible adoption into the lease management program in connection with the work being done in this area by the committee on standards and specifications.

Recommendation No. 7. Engineering Documentation

Action Taken: The current proposed revision of OCS Order No. 8 includes requirements on documentation as recommended by the studies.

Recommendation No. 8. Wearout Prevention

Action Taken: The proposed revision of OCS Order No. 8 includes an erosion control program. This is also the subject of one of the research and development committee's projects.

Recommendation No. 9. Training

Action Taken: A committee has been formed in conjunction with the API on offshore safety and anti-pollution training and motivation. This committee is outlining the training needed for personnel working offshore, setting up training programs, and establishing a time-framework for accomplishing this. The Geological Survey is establishing a more formalized training program for their own personnel and have plans for developing a training course in OCS Orders and regulations for presentation to the industry.

Recommendation No. 10. Motivation Program

Action Taken: The API and oil industry are taking the lead in developing a motivation program.

Recommendation No. 11. Lease Management Program

Action Taken: Additional personnel have been hired for the Gulf of Mexico OCS Office. The areas of responsibilities and goals of the individual organizational units are being developed. Also under development is a system for incorporating reports from other program areas into an annual review.

Recommendation No. 12. Inspection Procedures

Action Taken: Data processing equipment has been installed in the Gulf of Mexico area office. Inspection checklists are being updated to keep current with OCS Orders. Special inspections are conducted bi-monthly as data gathering exercises. Consistent enforcement policy is being applied in each OCS area. Computerized data files regarding inspections, platforms, and accidents have been established and are used as input for the safety review committee.

Recommendation No. 13. OCS Order Development Procedures

Action Taken: The Geological Survey is currently developing formalized procedures for the evaluation and revision of existing OCS Orders and the development of new OCS Orders. Proposed new and revised orders are now being published in the Federal Register for public comment prior to their adoption.

Recommendation No. 14. Standardization of Pollution Report Form

Action Taken: This form is currently being revised by the area offices.

Recommendation No. 15. Safety and Advisory Committees

Action Taken: The industry has established a committee on OCS Safety in both the Gulf of Mexico and Pacific Areas. The area offices have designated personnel to form systems analysis review committees to meet on a regular basis. These committees have had their initial meetings. The Director of the Geological Survey has formed a review committee on safety of OCS petroleum operations. This committee is composed of experts not regularly employed by industry or the Government and is sponsored by the Marine Board of the National Academy of Engineering. The initial meeting of this committee was held in Washington, D. C. during August 1973, and the next meeting was held in New Orleans, Louisiana during the later part of November 1973.

In addition to the above studies and reports, the General Accounting Office issued a report at the request of the Conservation and Natural Resources Subcommittee of the Committee on Government Operations, House of Representatives 1/. This study, like those mentioned above, presents

1/ General Accounting Office, "Improved Inspection and Regulation Could Reduce the Possibility of Oil Spills on the Outer Continental Shelf", Report No. B-146333, June 29, 1973.

a critical review of OCS regulatory and inspection procedures and includes recommendations designed to achieve more effective capability and procedures. In a letter dated August 3, 1973, from Secretary Morton to Mr. Henry S. Reuss, Chairman of the Conservation and Natural Resources Subcommittee, it is pointed out that the recommendations contained in the GAO report which have not already been implemented are being implemented as part of the Work Group's recommendations (see Vol. 3, Attachment D for the Work Group's recommendations).

Many of the recommendations contained in the GAO report were also made in the studies discussed above. Nevertheless, the following statements specifically apply to the GAO report:

1. Inspectors are instructed to apply prescribed enforcement actions for violations of OCS Orders unless deviations have been authorized and properly documented for each case by the Chief, Conservation Division, Geological Survey.

2. The inspection staff is to be increased and the number of inspections, both scheduled and unannounced, have been increased.

3. Inspections include workover and remedial operations as well as drilling, producing and abandonment operations.

4. Work groups have been formed to study the feasibility of:
   a. Requiring operators to submit a preventive maintenance schedule.

   b. Requiring operators to perform scheduled inspections and report results in a specified format.

5. GS is working with industry and with the API in an attempt to set standards and requirements for training personnel. GS personnel would participate in this training. In the meantime, Conservation Managers have been instructed to initiate formalized training in inspection procedures.

6. Plans are being adopted to limit the conditions under which multiple operations may be conducted for a single platform.

In early fall, 1973, a comprehensive report of a technology assessment of oil and gas operations on the U.S. Outer Continental Shelf was published by an interdisciplinary research team from the Science and Public Policy Program at the University of Oklahoma 1/. The independent analysis, funded by the National Science Foundation, was conducted over a 20 month period beginning in September, 1971.

The principle conclusions of the study are: (1) That existing OCS technologies are adequate for continued oil and gas operations; (2) that more sharply defined concerns for safety and environmental protection continue to pose a challenge to OCS management even though technologies responsive to these new concerns are gradually evolving; (3) that in the past, participation in the management of OCS oil and gas operations was limited to the Department of the Interior and the petroleum industry and that this relatively closed management system was initially unable to sense and respond quickly to a changing social climate. Interested groups and Federal agencies representing concerns such as environmental conservation are now participating in the management system primarily through the impact statement process required by NEPA. These new participants are demanding changes from past patterns of operations; and (4) but most of the new demands being made on OCS technologies are well within state-of-the-art. The necessary information modifications in the physical

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1/ The Technology Assessment Group, Science and Public Policy Program, University of Oklahoma, Energy Under the Oceans: A Technology Assessment of Outer Continental Shelf Oil and Gas Operations, University of Oklahoma Press, September, 1973.

technologies required by a changing social climate can be met. Although the application of stringent environmental and safety criteria pose problems, the industry either has or can develop the required physical technologies and procedures.

3. Ongoing Contracts and Inhouse Efforts

As an integral part of its OCS leasing program the Bureau of Land Management has undertaken a broad-based inhouse and outside contract study effort to aid in the implementation of the OCS leasing program.

The Bureau has awarded five contract studies for the purpose of gathering and consolidating available environmental and socio-economic data in the Atlantic, Gulf of Alaska, the Gulf of Mexico, and offshore Southern California. The areas of primary interest in the environmental studies are coastal zone climate, ecology, physical properties, man-made features, hydrography and continental shelf physical oceanography, meteorology, geology, and marine ecology. The socio-economic studies will review industrial and commercial activity, petroleum industrial development, demography, land and water use, sources of pollution, and existing transportation systems. The studies are scheduled for completion in June, 1974. The Southern California study will be completed in fall '74.

The specific areas being studied and identification of the contractors are as follows:

1) The North Atlantic - from the Bay of Fundy to Sandy Hook, New Jersey - awarded to the Research Institute of the Gulf of Maine (TRIGOM) of Portland, Maine, in conjunction with the Public Affairs Research Center, Bowdoin College and the University of Rhode Island.

This study will include the environmental and socio-economic aspects of mineral leasing in this area. TRIGOM will also supply environmental data for an oil spill computer model being used in the Council on Environmental Quality's study on the environmental impact of oil and gas production on the Atlantic OCS.

2) The Mid-Atlantic - from Sandy Hook, New Jersey to Cape Hatteras, North Carolina - awarded to the College of Marine Studies, University of Delaware of Newark, Delaware. This contract includes the gathering of socio-economic data pertaining to mineral leasing on the Outer Continental Shelf in this area. Environmental data pertaining to this area were gathered in a previous draft study. 1/

3) A study of the Gulf of Mexico was awarded to Environmental Consultants of Dallas, Texas. The contract calls for an updating and broadening of the Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR) Bibliography that was published in 1972 by the U.S. Department of Commerce's National Oceanic and Atmospheric Administration. The contract also provides for identification of research in progress relating to CICAR categories and a socio-economic study of the Gulf of Mexico.

4) The Gulf of Alaska and adjoining OCS areas of the Pacific Ocean, Cook Inlet to Unimak Island - was awarded to The Arctic Environmental

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1/ Dept. of the Interior, Bureau of Land Management, December, 1972. Library Research Project Mid-Atlantic Outer Continental Shelf (Reconnaissance), Draft Study.

and Data Center of the University of Alaska at Anchorage, Alaska. The study will include environmental and socio-economic data.

5) The study of the Southern California offshore continental borderland area was awarded to the Southern California Ocean Studies Consortium. This study will include the environmental and socio-economic aspects of mineral leasing in this area.

In addition, a contract for the development of an oil transportation computer model was awarded to Stanford Research Institute of Menlo Park, California. This model will aid in the analysis of Outer Continental Shelf oil resources and alternative sources of petroleum supply to help meet future regional demands and to assess the effects of prices and transportation costs relating to regional supplies and flow patterns.

Additional FY '74 funds have been transferred to the Council on Environmental Quality for a contract study on a data inventory of the southeast Atlantic coast.

In FY '74 the Bureau plans to conduct contract studies related to the gathering of specific information needed on the Gulf of Mexico OCS. The studies are to be completed in the fall of 1974. Study proposals are being designed to include a pipeline corridor analysis of the northeast Gulf, an environmental study (biological) of the continental

slope in the Gulf, and contingency plans involving both inhouse and contract efforts to analyze the effects of a major oil spill.

Inhouse environmental assessment teams are now operating in New Orleans, Los Angeles, Anchorage, and New York. Each team consists of various disciplines, including oceanographers, wildlife biologists, land use planners, recreation specialists and economists. One of the teams' primary responsibilities is to keep current with ongoing research efforts as they relate to the marine environment and maintains close liaison with state and local officials, and university and industry personnel. Close coordination is maintained so that the Bureau can receive the results of ongoing studies as quickly as possible and be aware of planned research efforts to minimize duplication. The teams prepare detailed descriptions of physical oceanographic and biological baseline data of the open ocean, and nearshore and estuarine areas in their respective study areas. Major wildlife and fisheries resources, conservation areas including parks, refuges, sanctuaries, aquatic preserves and areas of recreational activity and cultural or historical value are identified and included in environmental profiles. These profiles, analyses and data presentations provide the basis for preparing environmental statements which assess the impacts OCS activities potentially pose to the environment.

The preliminary feasibility studies underway by the CEQ concerning possible oil and gas leasing on the OCS in the Gulf of Alaska and

the Atlantic Ocean has underscored the importance protection of the environment will play in any determination concerning whether or not to open these frontier areas to OCS leasing. The environmental assessment teams will analyze the final studies in their respective areas and will plan and initiate studies on their own concerning potential environmental impacts of specific types of mineral exploration, leasing, development, and production in these areas.

4. Planned Study Efforts - FY '74

Funds amounting to $1.3 million have been allocated in FY '74 to conduct environmental baseline and monitoring studies in the areas that were leased in the December 1973, Mississippi, Alabama, and Florida oil and gas lease sale (OCS Sale #32). This study has been designed to gather baseline biological, geological, chemical and physical oceanographic data for those leases before exploration activities begin. This baseline data will be used for comparison with other data gathered after exploratory activities begin for the purpose of determining changes resulting from oil and gas exploration and development activities. Current plans are for the first set of samples to be taken before the end of May, 1974. Results of these and subsequent studies will aid in making necessary revisions in OCS operating orders, development plans, and in granting pipeline rights-of-way on the OCS. Initial work on the study plan and the first contract Request for Proposals (RFP) was completed by an Interagency Management Advisory Committee chaired by BLM and consisting of representatives from

Bureau of Sport Fisheries and Wildlife, Geological Survey, National Oceanic and Atmospheric Administration, and Environmental Protection Agency with observers appointed by the Governors of Mississippi, Alabama, and Florida.

The Department has established an Outer Continental Shelf Research Advisory Board in accordance with the provisions of the Federal Advisory Committee Act (Public Law 92-463). This Board will advise the Assistant Secretary-Land and Water Resources, the Director of the Bureau of Land Management, and other Departmental officers in matters related to environmental baseline and monitoring studies on the Federal Outer Continental Shelf lands. A copy of the Board's charter is contained in Attachment Q.

5. Additional Study and Research Programs - FY '75

Funds amounting to $9.7 million have been allocated to conduct baseline environmental studies in five areas of the OCS during FY '75. In addition to a continuation of the study effort offshore Mississippi, Alabama, and Florida, baseline environmental research studies will be initiated offshore South Texas, Southern California, on the Atlantic and Gulf of Alaska OCS. If CEQ's study of the environmental impact of oil and gas production on the Atlantic OCS and in the Gulf of Alaska determines that development in these areas can proceed in an environmentally satisfactory

manner, lease sales in one or both areas will be scheduled for the earliest practicable time.

The kinds of data that will result from the environmental baseline and monitoring studies in these frontier areas of the OCS will enable the Department to make tract selections based on better prediction of potential environmental impacts of oil and gas leasing and development over the short-term, will contribute to the design of long-term leasing plans and objectives, and will provide bases for changes in, or additions to, OCS operating orders and procedures.

Funds amounting to $3.5 million have been requested from the Congress for FY '75 to expand the environmental studies program on the OCS in order to meet the President's directive of leasing 10 million acres in 1975. Sec. I.C. indicated that the Department has requested the views of all interested parties regarding possible leasing in 17 designated areas on the OCS. A portion of the requested funds will be used to consolidate available environmental and socio-economic data and identify data gaps for those OCS regions which are not presently in the Department's study program. These additional study regions include the Santa Barbara/Central California, Northern California, Cook Inlet, the Southern Aleutian Shelf, Bristol Bay, the Beaufort Sea, and the Chukchi Sea, as well as more intensive literature searches in the Atlantic. Short-term (less than two

years) field surveys will be also be initiated as specific critical data gaps are identified in the literature reviews. In addition to the environmental baseline studies already funded in the President's Budget, designs for further extensive and intensive baseline sampling and monitoring of OCS areas will be developed. The result will be a baseline sampling plan to support extensive monitoring needed to identify tracts in a region and for any subsequent extensive environmental monitoring of actual operations.

II. DESCRIPTION OF THE ENVIRONMENT

A. Geologic Framework 1/

1. General

Lease sale No. 36 includes tracts in all areas of the Louisiana Outer Continental Shelf (OCS), plus several 'deepwater' tracts in lease areas recently blocked-out on the upper part of the continental slope. A few tracts near the mouth of the Mississippi River lie on the upper part of the Mississippi 'cone'. Water depths above sale tracts range from 25 feet or less, near the Louisiana shoreline, to more than 600 feet on the continental slope. Figure 1 presents the general bathymetry of the lease area.

2. Geologic History and Structure of the Northern Gulf of Mexico Region

Louisiana's offshore continental shelf and continental slope represent only small parts of a single structural unit, the Gulf Coast basin (or geosyncline). The present-day Gulf of Mexico occupies the larger part of this structural basin. Onshore, to the north and west, the structural basin and its sedimentary deposits underlie the Gulf coastal plain, the physiographic unit which borders the Gulf of Mexico in Mexico and the southern states of the U.S. The continental shelf is the underwater extension of this generally smooth, gently-dipping coastal plain. A break in slope separates

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1/ Much of the material in this section was supplied by the U.S. Geological Survey.

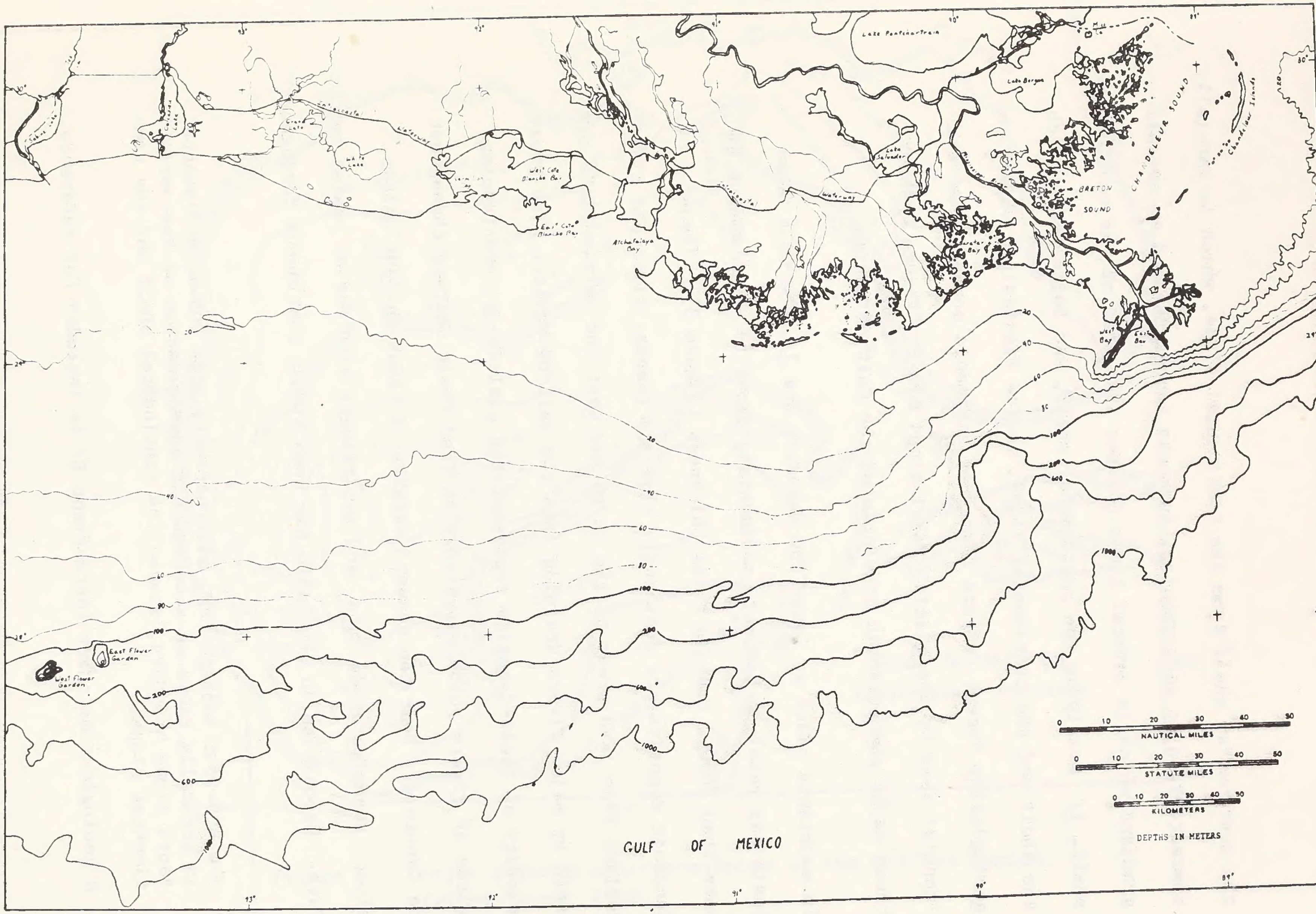

Figure 1 . General bathymetry of the Louisiana continental shelf and upper continental slope.

the continental shelf from the continental slope, which is generally characterized by an irregular, hummocky topography and an overall gradient which is several times steeper than that of the continental shelf. 1/ Overlying the continental shelf, and built across both the shelf and the continental slope, is the Mississippi 'cone', a geologically recent feature formed by sediments poured in at the 'cone's' apex by the glacial Mississippi River. Figure 2 shows these major physiographic provinces of the Gulf of Mexico.

In existence since at least the Mesozoic era 2/, the Gulf Coast basin has received Cenozoic sedimentary deposits which amount to more than 50,000 feet in total thickness (Figure 3). These Cenozoic deposits are dominantly clastics (sands, silts and clays), derived from land areas to the north and west and carried into the basin by major rivers draining into the Gulf of Mexico. The great majority of these deposits represent the coalescing, overlapping deltas of rivers which repeatedly shifted their courses throughout the Cenozoic. Near the seaward margins of these ancient deltas, deltaic deposits grade into, and interfinger with marine shales and clays. Deposition in the basin has been almost continuous throughout

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1/ The 600-foot isobath (or, alternatively, the 200-meter isobath) is generally taken as a convenient approximation of the variable-depth slope boundary between the continental shelf and the continental slope.

2/ A geologic time chart (Attachment E) is included for reference.

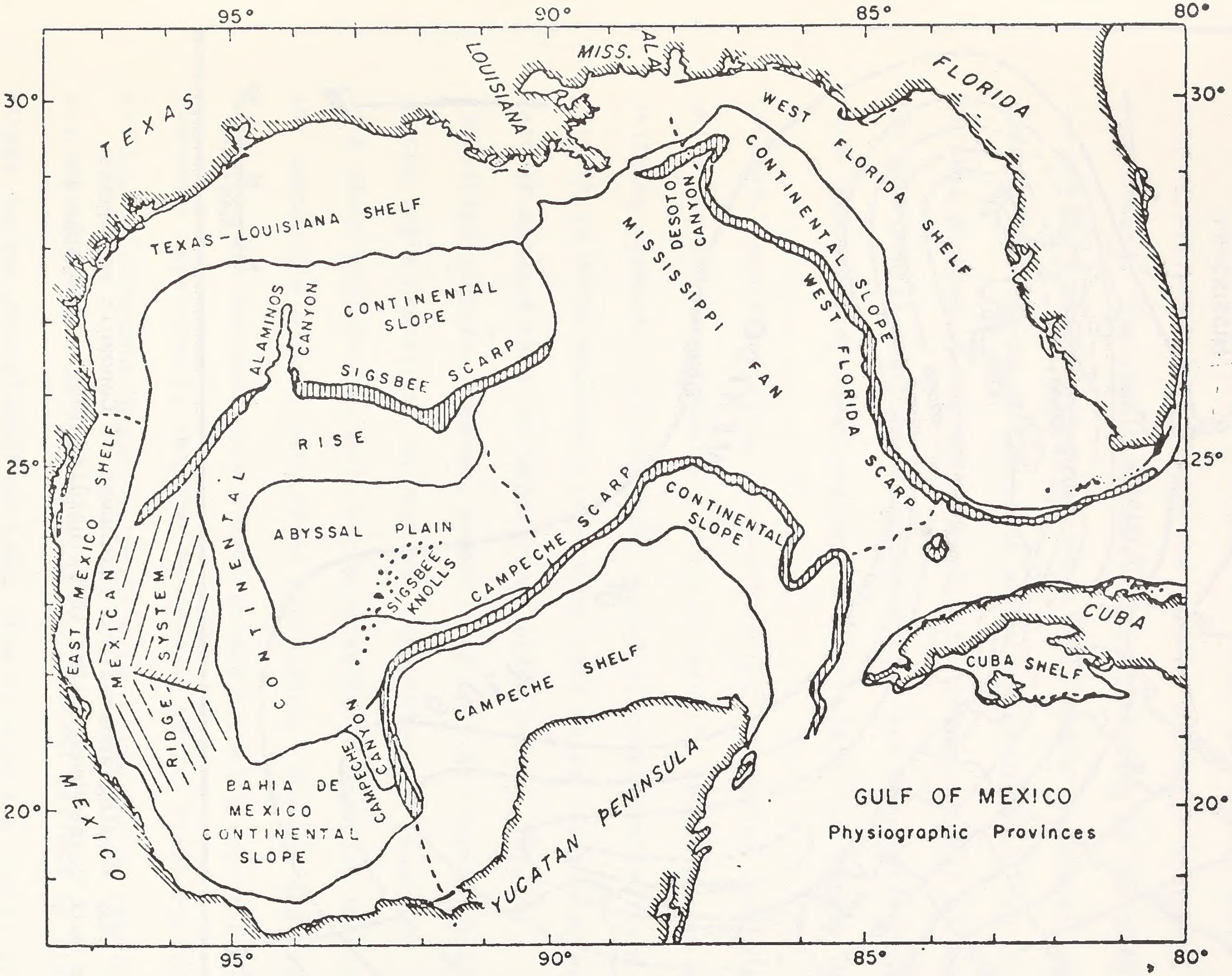

Figure 2 . Major physiographic provinces of the Gulf of Mexico. (after Bouma, 1968).

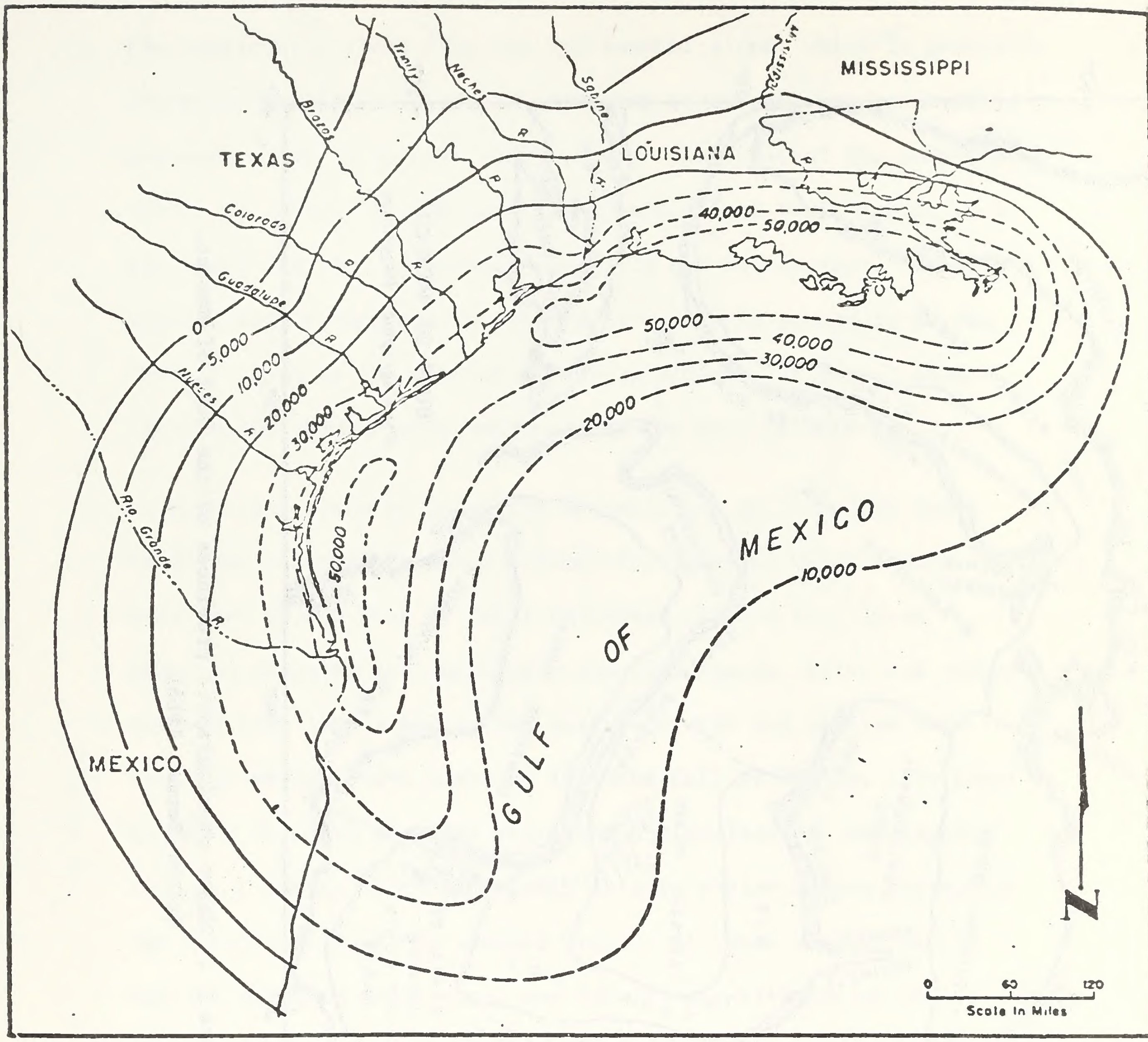

Figure 3 . Map showing generalized thickness of Cenozoic sediments in the Gulf Coast Geosyncline (From Hardin, 1962). Isopachs in feet.

the Cenozoic era, with slow, general subsidence of the basin floor keeping approximate pace with the rate at which the sediments accumulated. The result has been partial filling of the Gulf Coast basin with a thick sedimentary rock wedge which pinches out updip towards the margins of the basin and thickens seaward. In terms of that portion of the sedimentary wedge below the Gulf of Mexico, the continental shelf is its upper surface and the continental slope its seaward, advancing margin--the 'blunt' end of the wedge.

Cenozoic deposition along the northern Gulf of Mexico took place while the sea was generally retreating and the shoreline gradually shifting seaward. The resulting deposits, consequently, form a pattern in which successively-younger rock units occur progressively farther seaward than the underlying, older units. This is a simplified picture, however, summarizing only an overall aspect of the era's deposits. In reality, deposition was generally cyclic, with minor periods (cycles) of transgression repeatedly interrupting the Cenozoic's overall pattern of regression. Miocene and Pliocene deposits, for instance, are characterized by thick regressive sequences separated by thin but widespread marine transgressive shales. Pleistocene deposits, which were controlled by sea-levels which fluctuated from low stages during glacial periods to high stages during interglacial periods, show alternating cycles of regression (glacial) and transgression (interglacial).

In Louisiana offshore areas, rocks representing only the youngest subdivisions of the geologic time-scale are present above 20,000 feet, the maximum depth to which any Louisiana OCS well has been drilled. Figure 4, a schematic cross section from south-central Louisiana to the Sigsbee Escarpment, illustrates the thickness and gross depositional facies of Pleistocene sediments. Areas within the section where land-derived sands (reservoir strata) are interfingered with organic-rich marine clays and shales (source beds) provide a favorable environment for the genesis and accumulation of hydrocarbons.

Individual beds of rock within the upper Cenozoic sedimentary complex are seldom traceable over long distances. Rock formations in the conventional sense (mappable units of relatively constant, recognizable lithology) do not exist in this thick body of alternating, complexly interfingering sands and shales. Regional geologic mapping, however, is still possible through the use of biostratigraphic zones which subdivide the sedimentary rock complex into time-rock units approximately equivalent to formations. Faunal "tops"--thin but regionally-persistent marine shales containing abundant microfauna form the upper boundaries of biostratigraphic zones which extend downwards to the next faunal "top". The faunal-"top" shales represent transgressive cycles; the much thicker sections below them are deposits laid down during one major regressive cycle.

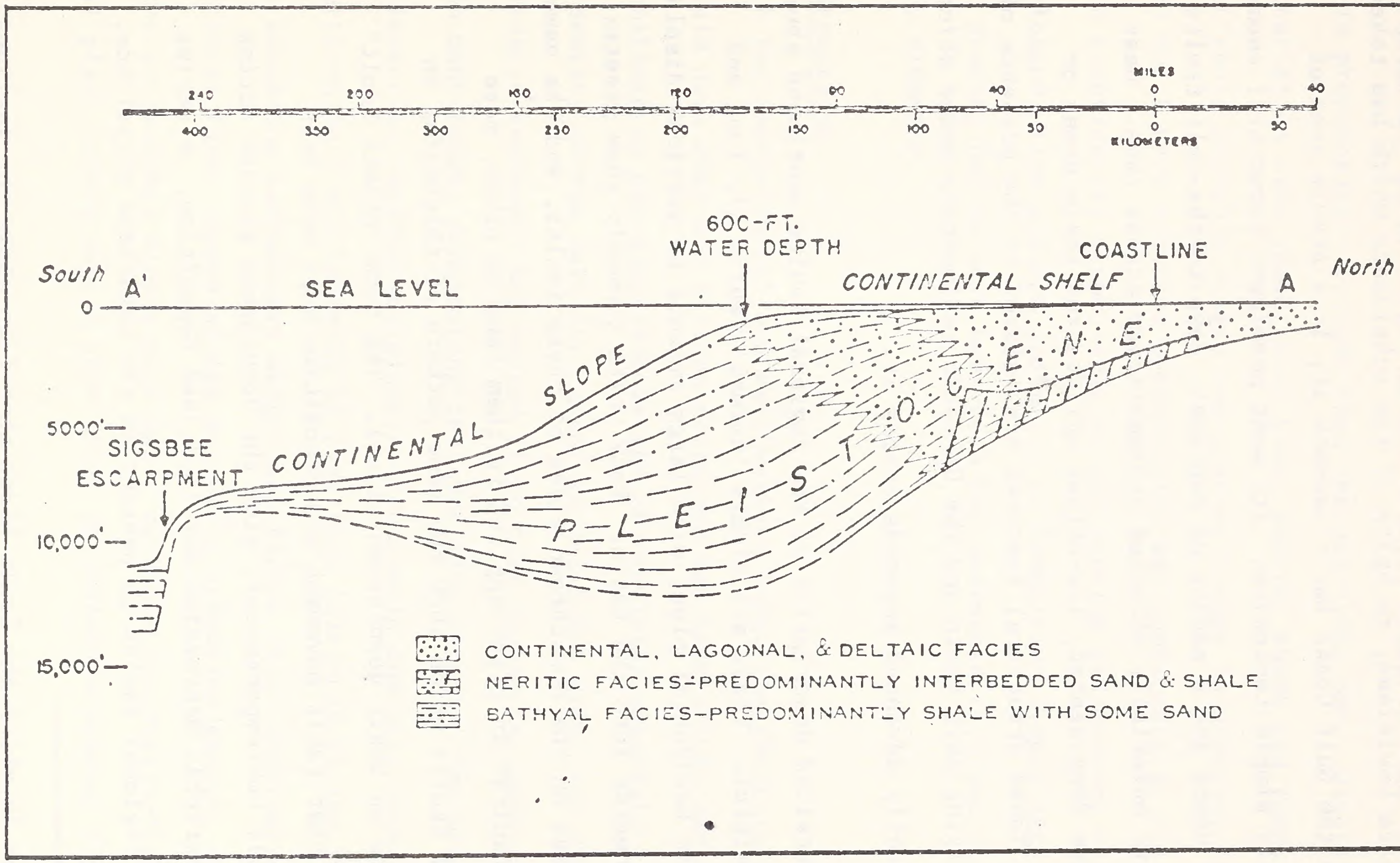

Figure 4 . Schematic N-S cross section of Pleistocene deposits offshore Louisiana (after Powell and Woodbury, 1970)

Offshore Louisiana, in spite of the subsidence which has taken place in the Gulf Coast basin beneath it, is a stable area of relatively simple tectonics. Its most prominent structural anomalies are salt domes and a series of regional, down-to-the-Gulf faults which have materially affected sedimentation across them. Less common are deep-seated, low-relief uplifts and shale domes or ridges. These structural features are related to the presence of an underlying salt basin and the Cenozoic sedimentary wedge which has gradually advanced seawards across it.

A more detailed description of the regional faults mentioned above may be helpful. These are always 'normal' faults 1/, long and arcuate in horizontal plan, with large amounts of vertical displacement downwards into the basin. Rock units commonly show greater thicknesses on the downthrown sides of these faults, and the name "growth faults" is often applied to them (and to other, more localized faults which show the same pattern of thickening in rock units on their downthrown sides). The term "growth fault" suggests that fault movement and deposition must have been essentially contemporaneous, with the downthrown section acting as a topographic depression for localized deposition. A series of these regional faults is present in the Louisiana subsurface,

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1/ Faults in which the fault block that lies above the inclined fault plane appears to have moved downwards relative to the block below the fault plane.

in approximately parallel alinements. Going seawards, each successive fault is progressively younger than the preceding one. Distributional characteristics like these, plus their general shape and form, suggest their probable origin--as gravity slumps (underwater landslides) which have occurred periodically and repeatedly at the seaward (continental slope) edge of the growing sedimentary wedge. Water-logged, fine-grained sediments on transition slopes near the end of growing deltas must have been the sediments involved in this gravity slumping.

Salt Structures

Beneath the north-central and northwestern Gulf, the thick layer of salt laid down over 100 million years ago has been slowly deformed and mobilized by the excessive weight of overlying material. The lower density of the salt (2.2 g/cm^3 vs. $\sim$2.5-2.6 g/cm^3 for overlying consolidated sediment) has caused it to rise buoyantly, upwarping and, in many cases, penetrating the overlying strata. The processes of differential loading and plastic flow within the salt beds of the northern Gulf are believed to have been initiated at the front of the advancing sedimentary wedge (see Figure 5.) Underwater depositional fans, formed at the mouths of submarine canyons eroded into the continental slope, were built up above the nearly-flat abyssal plain, where only a thin layer of sediments covered flat-

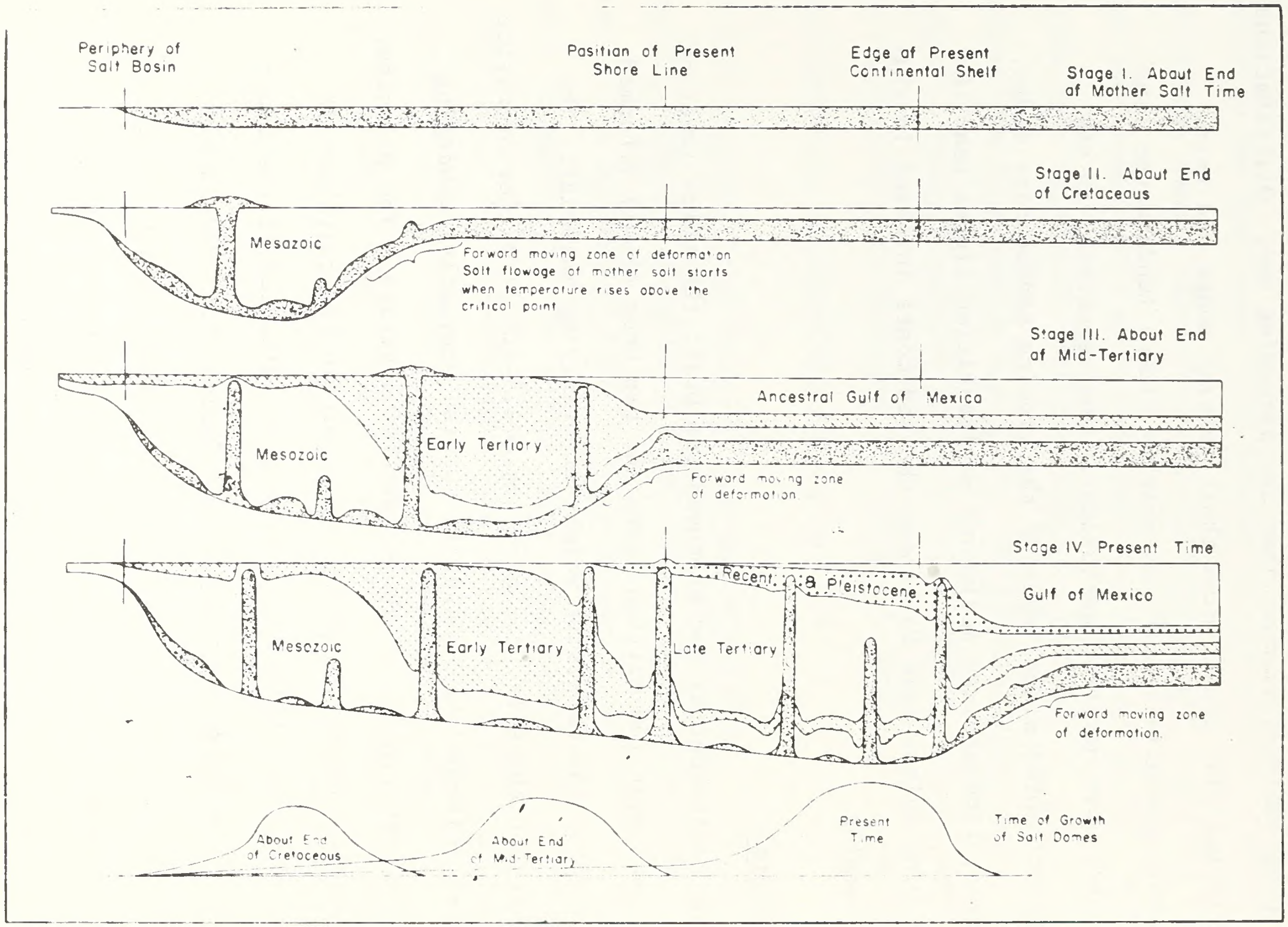

Figure 5. Development of Gulf Coast salt domes through geologic time. (from Gussow, 1965; after Hanna, 1959)

lying beds of the salt basin. Plastic flowage induced in the salt by the weight of the sediments in the overlying fans moved salt outwards from beneath them. Rates at which the salt flowed outwards evidently exceeded the rates at which new sediments were added to the fans, so that the eventual result was the conversion of the fans from topographic highs into topographic lows. The new depressions continued to localize sedimentation within them and, in turn, the outward movement of salt continued. Outward lateral growth of these depressions, as sediments continued to move down the submarine canyons and into them, first divided the flat-topped salt mass into salt plateaus and intervening topographic lows. Continuing enlargement and eventual coalescence of the sediment-trapping depressions, accompanied by further squeezing-out of the salt from beneath them, led to dissection of the intervening salt plateaus, first into peripheral ridges and later into elongate ridge segments and individual broad salt masses. This latter stage is thought to be the stage of development reached beneath the upper part of the present continental slope, accounting for its chaotic, hummocky topography. Salt domes, as such, are products of a later stage, beginning only after the growing continental shelf has advanced outwards across the salt structures of the former continental slope. The same processes of differential loading, now manifested by greater deposition within the old sediment-trapping depressions than across the salt highs,

continued the further depression of the lows and the concomitant lifting of the highs. During this continental-shelf stage, upward salt influx occurs from the outer flanks of the original salt ridges and salt masses. The process operates to reduce cross-sectional areas of these salt bodies and to uplift them; it continues until flanks of the developing salt dome have become almost vertical.

Piercement salt domes (diapirs) are associated with the continental-shelf stage. These are salt spines which grow upward from an underlying, larger salt mass. Typically, they 'break' through the sedimentary-rock cover above them, carrying upward a sedimentary "lid" which is bounded by high-angle faults. The bounding faults radiate outwards from the salt core or, sometimes, are "trap-door" faults which lie tangent to a part of the salt dome. Salt domes probably 'break' through only once, responding to further pulses of uplift by movement along the pre-existing bounding faults without actually intruding the overlying rocks. Final stages of the growth of a salt dome result in the warping of the overlying beds into a gentle dome above the salt plug. A second set of faults, "stretch" faults which result from this 'stretching' of the overlying beds, is formed during this closing stage of salt-dome growth. Figure 6 shows the regional distribution of diapric structures within the Gulf of Mexico.

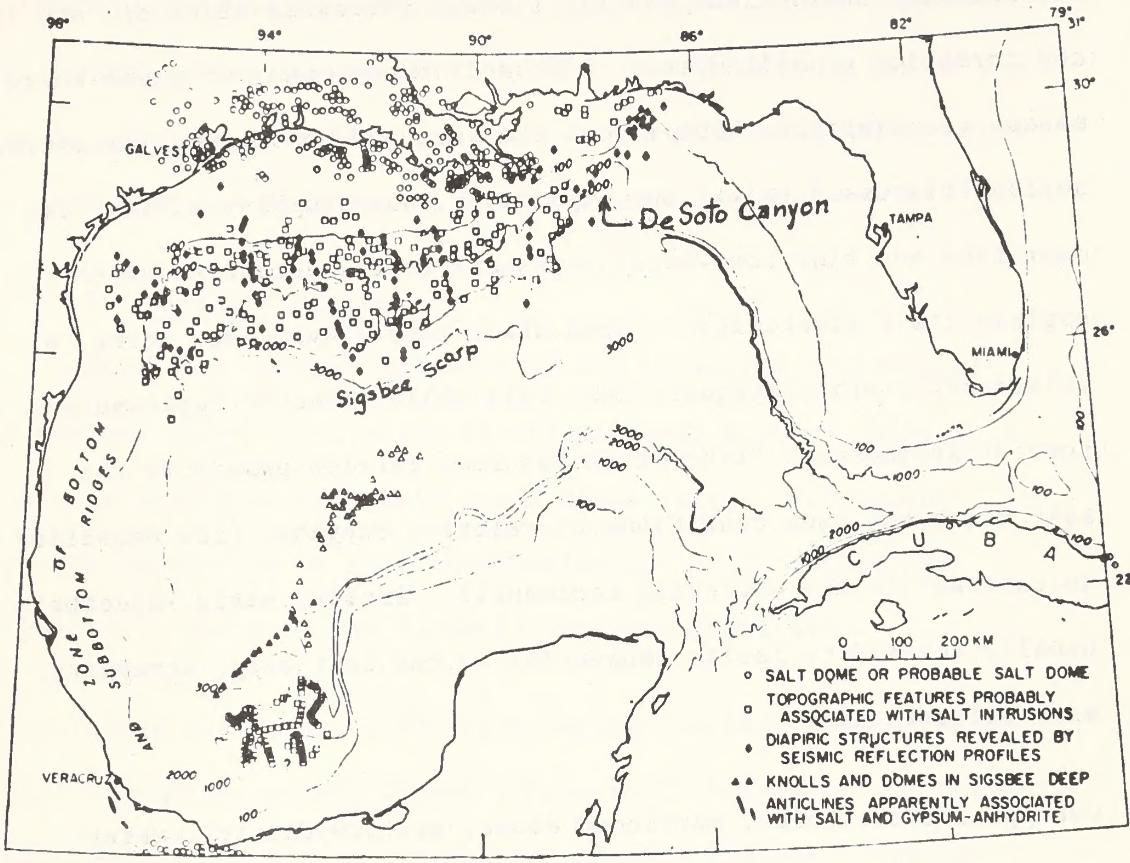

Figure 6 . Distribution of diapric structures in the Gulf of Mexico (From Uchupi and Emery, 1968)

Shale ridges and shale domes are the end-products resulting when some deepwater marine shales are subjected to essentially the same differential loading and plastic flowage processes which operate in the formation of salt domes. Like salt domes, many of these shale masses are diapiric. Not all of them are made up of over-pressured shales (discussed below) but, typically, they display similar low densities and high pore-water pressures (characteristics which explain their plasticity). Some shale masses have salt cores, a relationship which suggests that this shale "sheath" represents a form of sedimentary "lid" which has been carried upward by the salt under the same conditions of relative buoyancy (low densities in contrast to the enclosing sediments). Partial shale "sheaths" usually related to faults tangential to the salt body, accompany many salt diapirs.

Over-pressured shales, mentioned above, are low-density, water-saturated clays (not true shales) in which the pore-filling water shows fluid pressures considerably greater than would normally be expected at their depths of burial. These clays are appreciably lighter than normal shales and may be even lighter than salt. A synonymous term--under-compacted shales--helps explain their origin. Compaction of these clays has been interrupted, probably because deposition of the over-lying sediments was too rapid to allow normal expulsion of water from their pore spaces. In mechanical terms, their abnormally

high fluid pressures result because pore water, rather than the rock-matrix, is now bearing the bulk of the overburden pressure. When lenticular sands are isolated within bodies of over-pressured shale, 'geopressured reservoirs' result. Over-pressured shales are common in offshore Louisiana, generally at depths below 10,000 feet where marine shales predominate in the section.

3. Surface Sediments

Surficial bottom sediments of the Louisiana continental shelf reflect only a thin slice of its geologic history, dating back to the last time the shelf stood above water. Subsequent underwater deposition by shifting Mississippi River deltas has only partially covered this formerly emergent shelf area.

Sea level lowering of about 450 feet during the last glacial stage of the Pleistocene reached almost to the outer margin of the present-day continental shelf. It exposed the shelf's Prairie formation surface 1/ to subaerial weathering and to erosion by coastal streams which became deeply entrenched in the shelf. Sediments carried by the Mississippi River were carried across the emergent shelf and deposited directly onto the Mississippi 'cone', above the con-

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1/ Prairie formation rocks are exposed onshore in the Prairie terrace, the lowest and youngest of a series of stepwise Pleistocene terraces which rise gradually northward. Seaward dip of the Prairie terrace carries it underneath the Mississippi River deltaic plain into the Gulf of Mexico. Its underwater surface, only partially covered by younger deposits, is basically the surface of the Louisiana continental shelf.

tinental slope. Mississippi River discharge, during this regressive-sea cycle, flowed into the head of the Mississippi trough, a submarine canyon located about 50 miles southwest of the river's present course.

During the subsequent rise of the sea to its present level, deltas of the Mississippi River laid down the thick complex of deltaic deposits which overlap the eroded Prairie formation surface in central and eastern parts of the Louisiana continental shelf. The extent of this overlap is indicated in Figure 7, which gives the general source and distribution patterns of recent sedimentation within the north-central and northwestern Gulf of Mexico. Shelf zones identified in the figure as areas of "no or very slow deposition" represent relict Prairie terrace surfaces which have received little recent sediment; coastal rivers, such as the Sabine and Calcasieu, that would normally supply material to these areas are instead depositing their relatively small sediment loads along upstream segments of their entrenched valleys.

The site of active deltaic buildup along the Louisiana coast has shifted several times during the past million years. Kolb and Van Lopik (1966) identify at least seven sub-deltas of the Mississippi delta-complex (Figure 8). The river's modern 'birdsfoot' delta, the Balize lobe, extends underwater almost to the continental slope, and represents the uppermost part of the Mississippi 'cone'. Stone (1972) has analyzed other segments of the Louisiana coast and

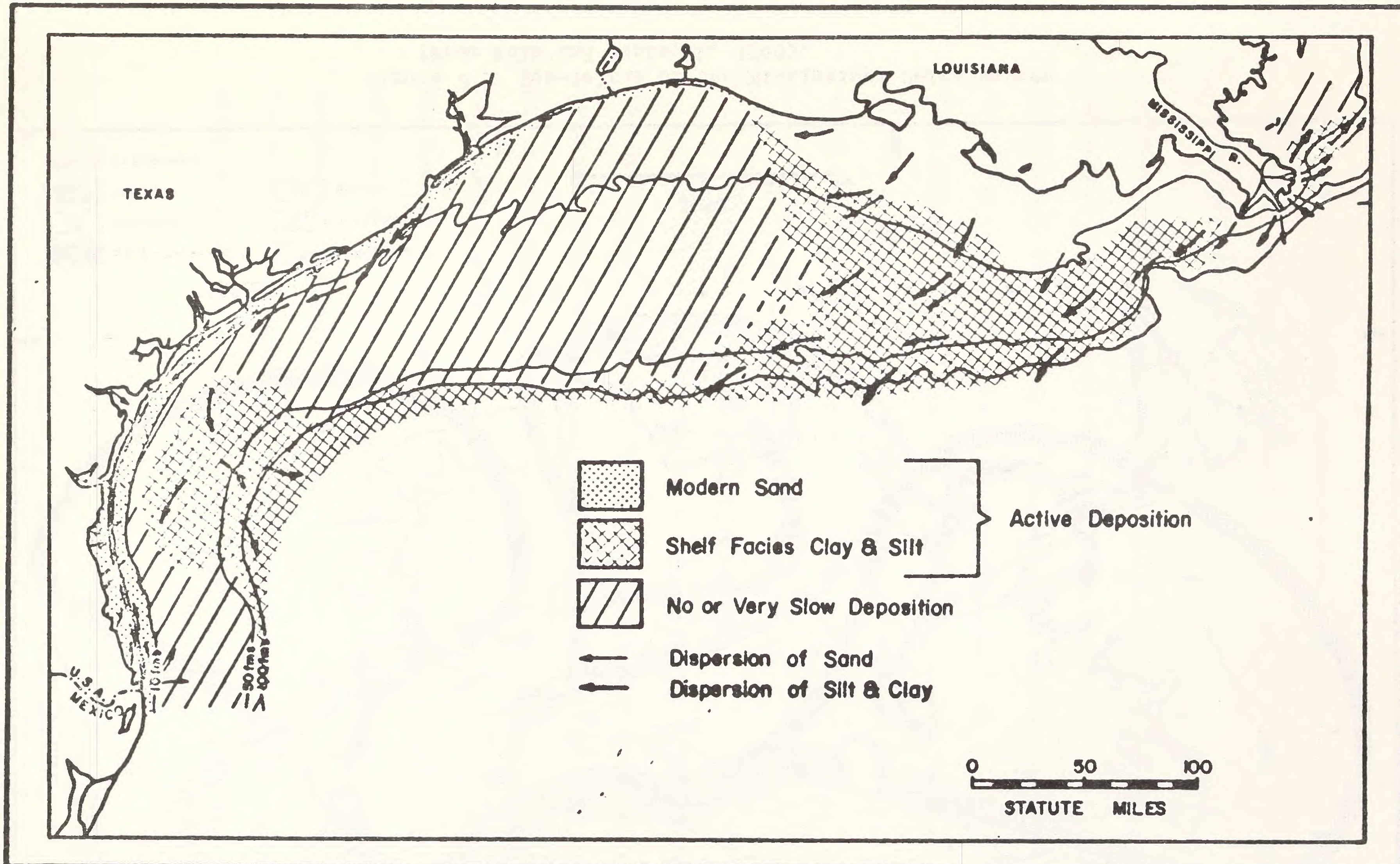


Figure 7. Depositional and sediment dispersion patterns, northwest Gulf of Mexico (from van Andel, 1960).

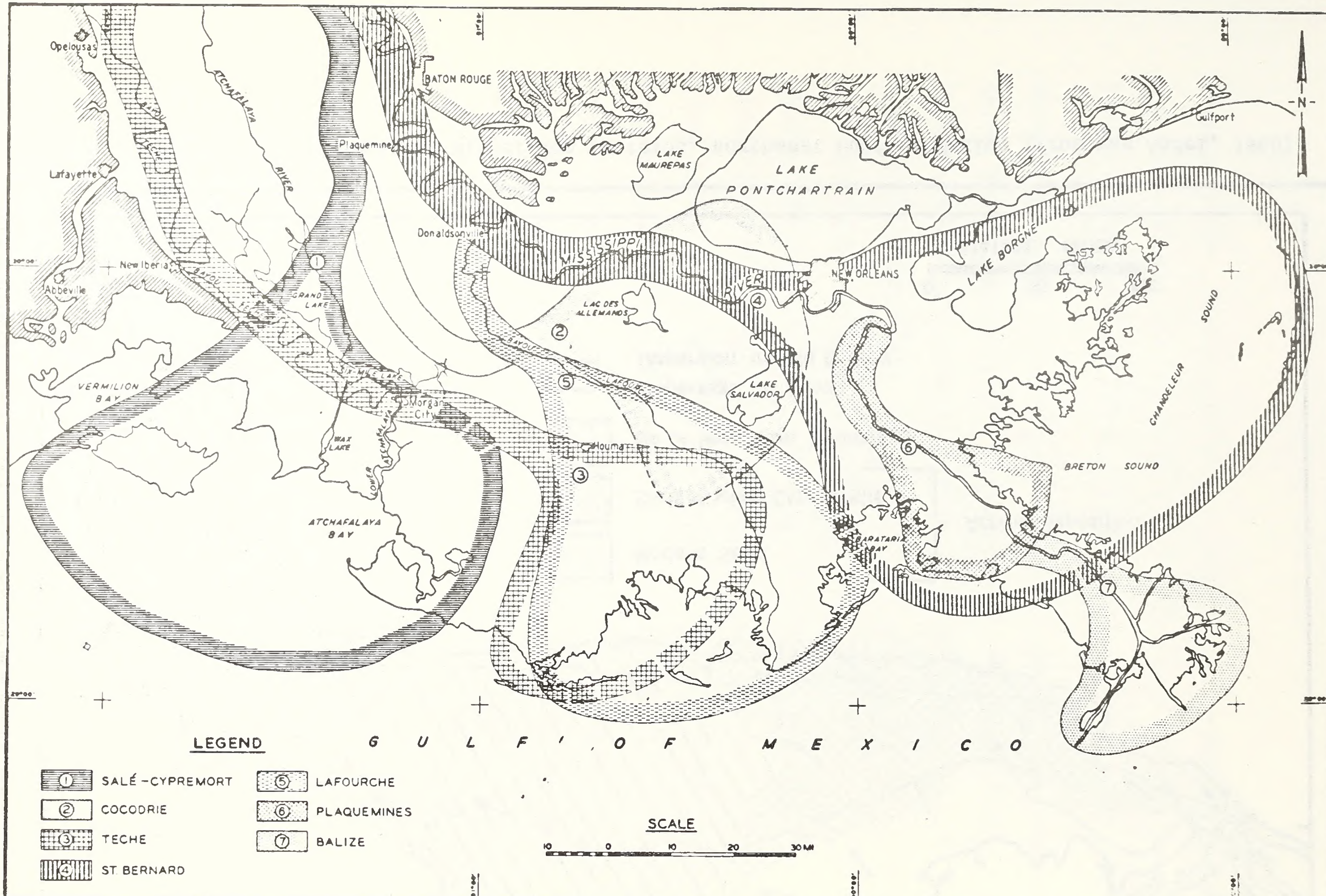


Figure 8. Sub-deltas of the Mississippi Delta system (From Kolb and VanLopik, 1966).

believes the Atchafalaya (off Vermilion) delta is also advancing, while both the Barataria (12-25 ft./yr.) and Terrebonne (25-50 ft./yr.) coastlines are retreating.

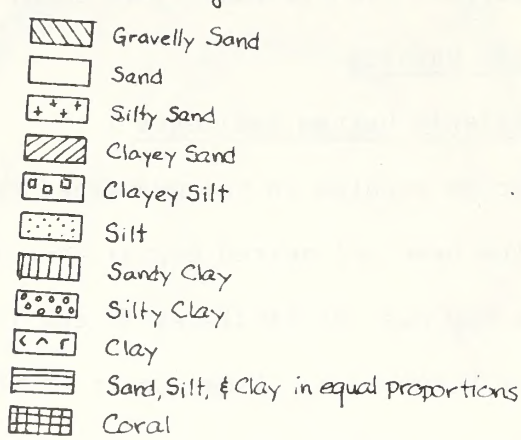
Surface sediment distribution on the Louisiana continental shelf, at depths less than the 200-meter isobath, is shown on Figure 9 . In general, Prairie formation deposits are coarser-grained (sands and silts) than the younger deltaic deposits (silts and clays). This generalized difference shows up on Figure 9 as fairly large map areas of sand or silty sand in the western part of the shelf, where the Prairie terrace has not been overlapped.

4. Geologic Hazards

a. Unstable Bottom Sediments

Recent studies in the submerged Federal lands on the Mississippi delta have delineated certain areas in which unstable sediment conditions may pose difficulties in the location of sites for bottom supported structures. As a result of these studies which were conducted by the U.S. Geological Survey in conjunction with the Coastal Studies Institute of Louisiana State University, a map (Figure 10) has been prepared delineating areas within which adverse foundation conditions may exist in various regions of the delta. The nature of sediment instabilities is such that stable locations exist in areas where instability is most prevalent, but the map

Key to Figure 9



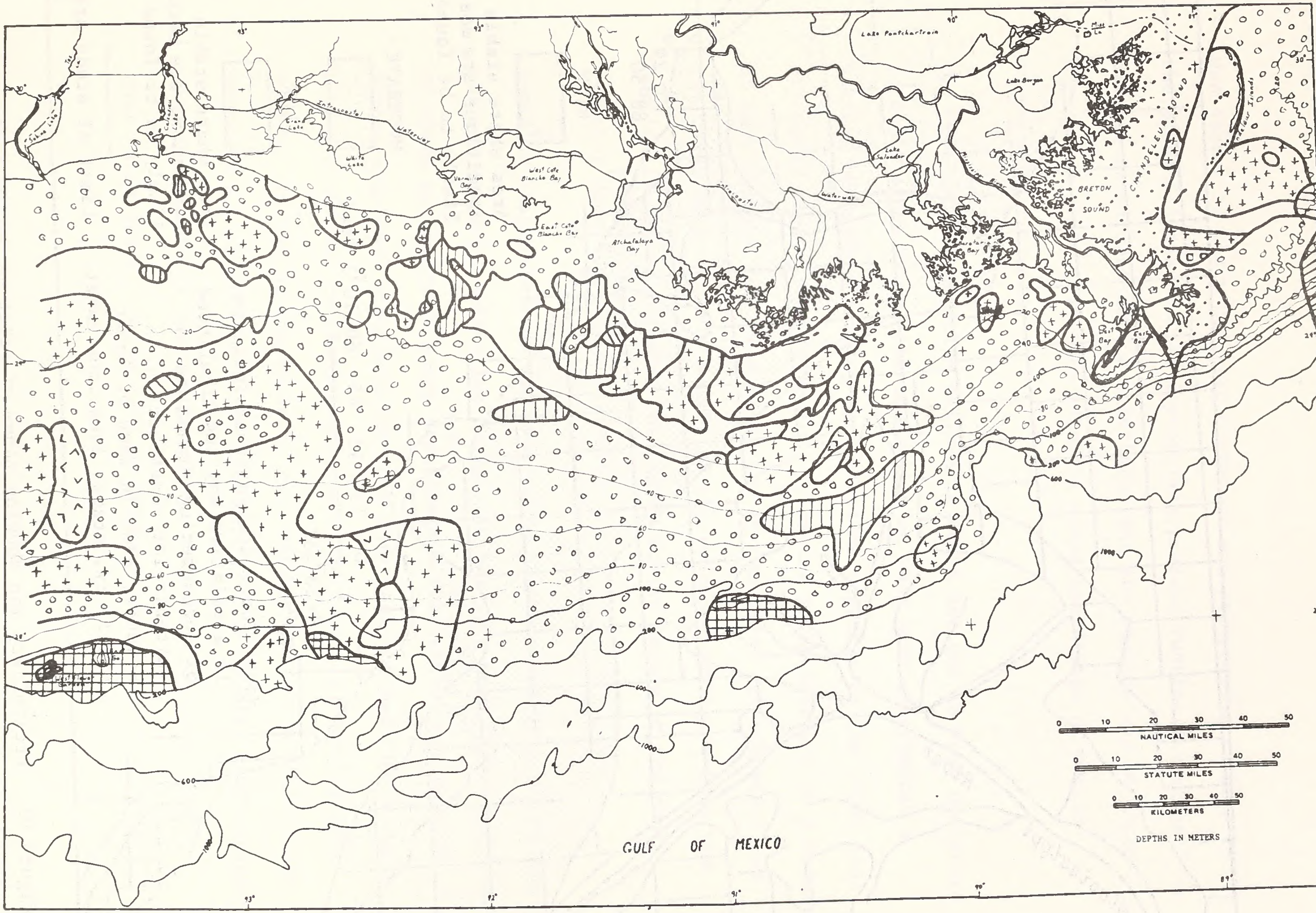


Figure 9. Surface sediment distribution.

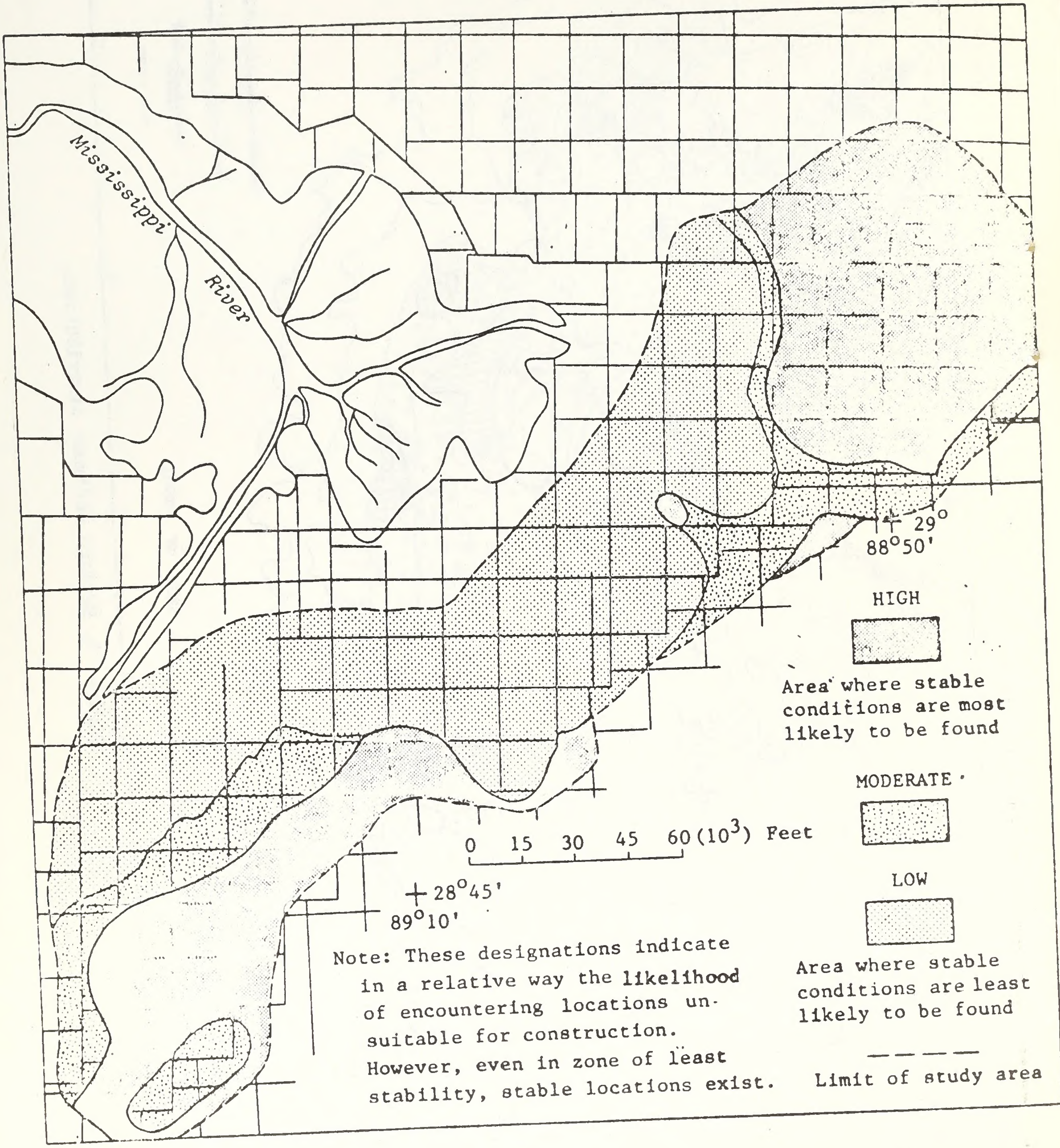


Figure 10. Preliminary map showing zones of relative bottom sediment stability. (U.S. Geological Survey, March 1974)

was issued to alert offshore operators and prospective lessees to the possibilities so that appropriate preconstruction investigations of soil conditions may be undertaken and the results can be incorporated in their selection of drill sites and design of bottom supported structures.

The problem of foundation failure is not a new one to most operators in delta areas around the world some of whom have experienced a variety of mishaps ranging from pipeline ruptures to the total loss of costly production platforms. Intensive investigations of a number of such mishaps have been conducted by the major oil companies and the Government, and the weight of the evidence indicates that the problem is associated with the highly mobile nature of the most recently deposited delta sediments.

While it is possible to cope with some of these unstable conditions through propoer engineering design, it has long been known that some of these geologically young deposits are frequently incapable of supporting heavy structures because they have not had time to gain strength through compaction and consolidation. In recent years, however, it has become apparent that under certain conditions such deposits are capable of local movement both in lateral and vertical directions. These movements, often occurring relatively rapidly over large areas, pose a type of hazard to sea floor structures

which is analogous to the hazard posed by landslides to structures on land. Sea floor movements are not as predictable as landslides, however, because they are generally the result of a complicated interplay of conditions and forces. Submarine movements, unlike landslides, sometimes occur on slopes which are almost negligible.

Some of the pioneering work in this field by Shell Oil Company (e.g., Sterling and Strohbeck, 1973; Bea and Arnold, 1973) suggests that in some cases fluctuating pressures within the upper 100 feet of sediment caused by storm waves may trigger a sediment failure. Other investigations conducted at Louisiana State University indicate the content of dissolved and undissolved gases in sediments may play an important role in their instability. Most students of the subject agree that for certain deltaic types, such as the modern Mississippi delta, the principal process which moves sediment seaward from river mouth to the shelf edge is a sort of plastic flow. The mechanism governing this process and the rates at which it occurs are just beginning to be investigated, and its role in local instabilities is yet to be evaluated.

Following preliminary work in delineating known areas of potential bottom instability, the Geological Survey will begin a program of research into the problem of unstable marine sediments to develop an understanding of the mechanisms governing these phenomena.

b. Seismic Hazards

Seismic risk areas were originally designated for all parts of the United States in 1947 by the Coast and Geodetic Survey and revised several times since then. Seismic risk is expressed in arbitrary numbers from 0 to 3. They are based on historical data considering only the intensity of an earthquake, not the frequency of occurrence, and express the anticipated damage that would occur in the area.

Zone 0 - No damage	Zone 1 - Minor damage
Zone 2 - Moderate damage	Zone 3 - Major damage

Louisiana lies in a seismic Zone 1 (Algermissen, 1969), in which there is possible damage from earthquakes which will range up to intensity VI (Modified Mercalli, M.M., scale). 1/ An earthquake of intensity VI (M.M.) occurred in Assumption County in 1930, and an earthquake of intensity V (M.M.) occurred in the Baton Rouge area in 1958. The stars on Fig. 11 indicate the earthquake epicenters. Delineation of seismic risk zones on OCS lands is difficult; it is mainly conjectural in areas of low and infrequent seismic activity like the Gulf Coast. Extrapolating from known earthquake epicenters on land, the National Geophysical and Solar-Terrestrial Data Center (of NOAA) indicates that the Louisiana OCS is probably Zone 0, or Zone 1 at most.

1/ The Modified Mercalli Intensity (Damage) Scale of 1931 describes earthquakes on a scale from I to XII. Intensity VI is felt by all but damage slight (cracked chimmney and some furniture moved).

Risk of massive landsliding with attendant minor tremors on the subaqueous parts of the Mississippi delta is probably slightly higher than on adjacent land areas. However, due to the overall geological similarity of the land areas surrounding the Gulf and the adjacent continental shelf, one can reasonably extend the seismic risk zone boundaries some distance offshore.

5. Oil and Gas Production

The environment of deposition is most significant in its relation to oil and gas production. Sediments deposited on the outer shelf and upper slope have the greatest potential for bearing hydrocarbons due to the following:

1) This is the location where coarser, nearshore sands interfinger with the organic-rich marine shales, thus providing an optimum ratio of sandstone to shale. The shale forms the source-rock which provides the oil and gas and the sandstone provides the reservoir into which the hydrocarbons migrate.

2) In this environment, the organic material deposited with the fine-grained clays and muds is preserved, and not oxidized as it might be in shallower, more turbulent water.

3) At this location, the increased overburden of the prograding shallow marine deposits over the plastic salt and marine shales initiates salt flow which triggers the growth of salt domes and regional expansion faults, thus providing potential traps for the hydrocarbons.

This environment, therefore, is the optimal one for providing the three ingredients necessary for the successful formation and accumulation of oil and gas--reservoir rock, source beds, and traps. Environments seaward of the outer shelf-upper slope have progressively less sand to act as reservoirs, and landward environments have progressively less source material, i.e., organic material.

A broad, gently sloping continental shelf holds more promise than a narrow, more steeply sloping one because bands of favorable environments in which rapid sedimentation is taking place and where organic sediment is quickly buried will be much wider. During the Miocene, Pliocene, and Pleistocene, large volumes of sediment derived from the Mississippi River system were supplied to the offshore Louisiana area. The Texas shelf, at the same time, received smaller volumes of sediment because it was on the western border of the Mississippi River depocenter.

Natural production of oil and gas frequently occurs along the continental shelf-slope break. Progradation of the north-central Gulf depositional regime has resulted in the migration of this production zone seaward, so that a series of progressively younger bands or trends is developed. Figure 11 shows the late Tertiary and Quaternary production trends which underlie the Louisiana OCS.

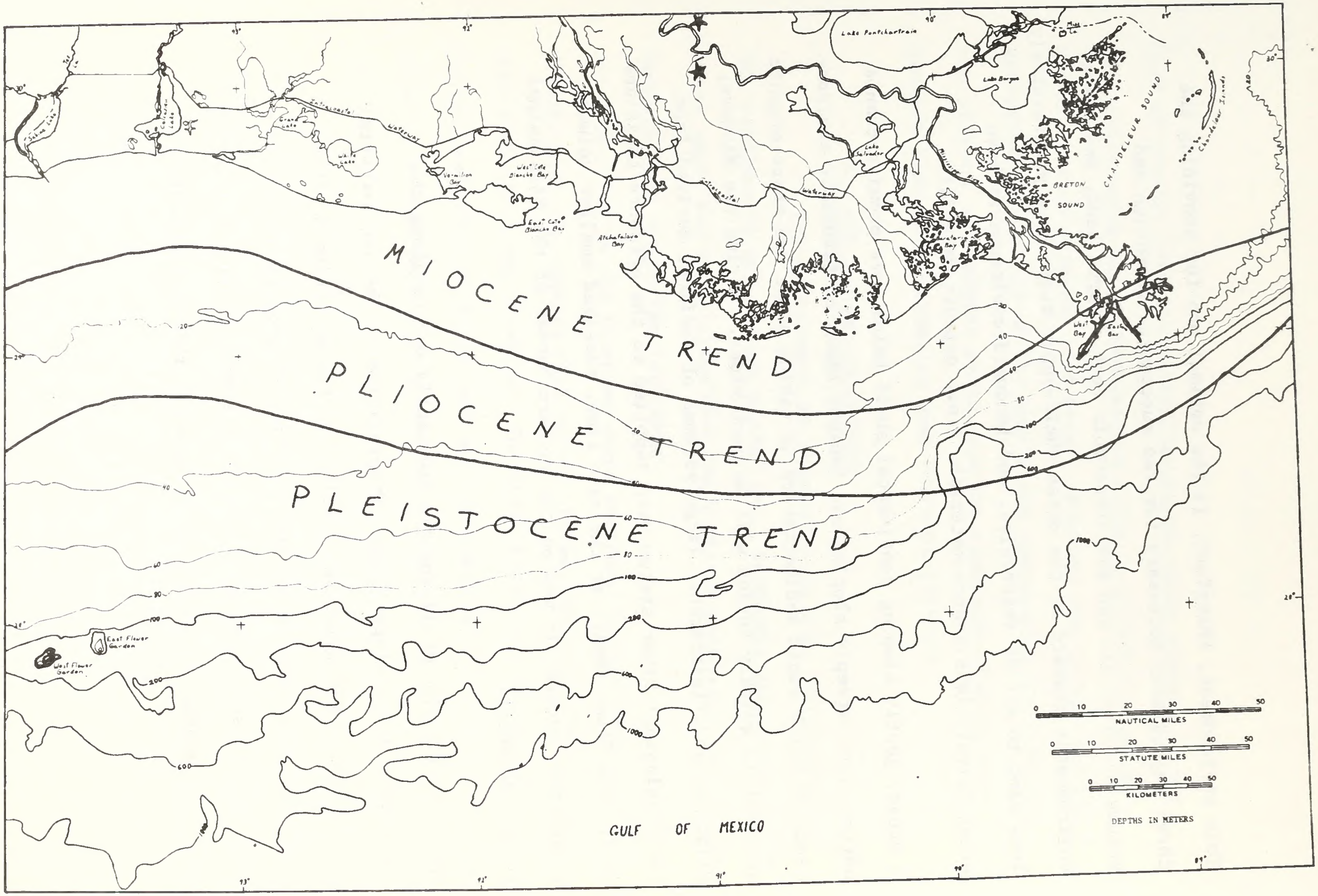


Figure 11. Hydrocarbon production trends offshore Louisiana.

There are approximately 186 fields on the Federal OCS of the Gulf of Mexico. Of these, 138 primarily produce gas and 48 primarily produce oil. Production depths range from about 1000 feet to 20,000 feet, with most production occurring between 8,000 and 12,000 feet. USGS records show that 3.152 billion barrels of oil and condensate and 19.8 trillion cubic feet of gas have been produced from Federal OCS lands as of October 1973.

The most prolific offshore production comes from the Miocene of the eastern Louisiana OCS. This area, as currently defined, has more oil than the remainder of the Texas-Louisiana area. The next most productive trend is the Pliocene trend of the central Louisiana OCS which produces about 50%-50% oil and gas. Farther to the west this trend probably dies out. The Miocene of western Louisiana is the third most productive trend producing mostly gas, and the Pleistocene of western Louisiana ranks fourth.

B. Climate of the North Central Gulf of Mexico and Adjacent Coastal Zone

The climate of the north central Gulf of Mexico is mild with a mean average temperature of 69° F. (20° C.), and considerable precipitation (59.20 inches, annual average). It lies in a transition zone between tropical and temperate climates. There are frequently-occurring long periods of stable humidity and temperature. The Gulf of Mexico is a source of warm, moist air through the spring and summer which serves to condition the coastal climate; these are the remnants of the tradewinds generated by the Bermuda high over the Atlantic Ocean.

The northern Gulf Coast is susceptible to severe tropical and extra-tropical storms and hurricanes in the fall and winter. In the fall, they are mostly tropical storms, but in the winter there frequently occurs a phenomenon known as a "norther" in which there can be generated short duration, high winds accompanied by cold weather.

1. Barometric Pressure and Atmospheric Circulation

Weather conditions over coastal Louisiana are dominated by the "Bermuda high" pressure cell centered over the west-central Atlantic Ocean and to a lesser extent during the warm months, the "Mexican heat" low pressure system centered over continental Mexico and west Texas. During the spring and summer months, the westward extension of the Bermuda high creates a predominantly easterly and

southeasterly flow of air currents bringing warm, moisture-laden air from the Gulf of Mexico over the Louisiana coast. In the fall and winter the increased strength of continental high pressure systems tends to force the Bermuda high to the southeast, and winds shift to a more northerly and northeasterly flow.

Average pressure conditions tend to be higher over the North American continent through January, but by early spring the Bermuda high has begun to migrate northwestward toward its summer position where it resumes dominance of the weather patterns in the northern Gulf of Mexico (Stone, 1972), and winds shift to a southeasterly origin.

Near the coast the winds are more variable than either onshore or offshore due to their proximity to moving cyclonic (low pressure) storms characteristic of the continent (U.S. Dept. Commerce, 1967). Average wind conditions for offshore Louisiana and Texas are shown in Figure 12.

Monthly wind conditions in these localities are presented in Table 5 and Attachment F; these show graphically the changes in influence of the Bermuda high. It should also be noted that wind velocities are considerably lower in the summer months (June, July, and August), averaging slightly less than nine knots than in the winter months (December, January, and February) when they average slightly more than 14 knots (U.S. Naval Weather Service Command, 1970).

Table 5. Monthly Summary of Percentage Frequency of Wind Direction and Average Speed in Knots. Data from U.S. Naval Weather Service Command, 1970a and 1970b. Summarized from 1881-1968.

NEW ORLEANS

	JAN.		FEB.		MAR.		APR.		MAY		JUN.		JUL.		AUG.		SEP.		OCT.		NOV.		DEC.		ANNUAL	
	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd
N	17.6	15.5	14.2	15.6	14.1	15.3	9.2	14.0	7.8	11.1	4.7	7.4	3.9	7.9	6.2	8.1	10.0	12.0	19.1	13.6	20.2	16.1	18.2	15.5	11.9	13.9
NE	15.6	14.3	15.5	15.1	15.6	14.2	11.5	12.8	11.4	10.9	7.9	9.4	5.9	8.5	10.2	9.6	22.3	13.3	27.8	13.5	18.5	14.1	17.2	14.2	14.9	13.0
E	17.2	12.8	16.8	13.6	17.6	12.8	25.4	12.2	26.5	11.8	22.2	10.4	17.9	9.4	21.4	9.7	30.6	12.5	25.0	12.5	21.2	12.8	18.6	12.7	21.7	11.9
SE	15.0	12.4	17.2	13.1	22.4	13.1	28.0	13.0	28.2	11.6	27.7	10.7	20.4	9.2	18.4	9.3	15.3	12.6	10.0	11.7	14.3	13.2	15.4	13.3	19.3	11.8
S	10.7	12.2	12.4	12.9	12.0	13.2	11.5	12.2	11.0	10.6	16.2	9.6	18.0	8.6	14.6	8.9	7.5	11.0	4.5	10.5	8.2	12.4	11.3	13.2	11.6	11.0
SW	4.2	12.0	5.2	12.3	3.0	11.0	3.2	10.5	3.5	9.3	6.1	9.2	10.6	9.0	8.6	9.3	3.7	10.2	2.4	10.8	3.4	10.8	3.7	11.5	4.9	10.1
W	6.5	17.5	6.8	15.3	4.4	14.9	3.9	14.5	4.1	9.4	5.3	8.6	9.9	8.7	8.5	8.8	3.7	10.0	3.0	11.7	3.7	12.3	4.5	14.1	5.4	11.7
NW	11.6	17.5	10.5	16.5	9.2	16.7	5.2	15.1	3.8	10.9	4.0	7.9	5.2	8.5	5.8	8.5	3.7	10.6	6.5	13.8	8.7	15.3	9.6	17.1	6.9	14.2
Var	0.0	--	*	3.5	*	4.0	0.0	--	*	4.0	*	5.0	*	2.0	*	2.0	*	3.0	0.0	--	0.0	--	0.0	--	*	3.5
Calm	1.5	--	1.3	--	1.6	--	2.1	--	3.7	--	5.8	--	8.2	--	6.6	--	3.1	--	1.7	--	1.8	--	1.4	--	3.3	--
Obs.	6512		6131		6830		6243		6315		7303		7253		7388		7074		7057		6472		6513		81091	

GALVESTON

	JAN.		FEB.		MAR.		APR.		MAY		JUN.		JUL.		AUG.		SEP.		OCT.		NOV.		DEC.		ANNUAL	
	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd	%	spd
N	18.0	16.0	15.0	15.9	13.9	15.2	9.5	14.5	6.9	11.9	3.3	9.0	3.2	7.2	5.4	8.7	10.7	13.0	18.3	14.1	18.7	16.0	18.7	16.2	11.5	14.4
NE	13.2	14.3	15.6	14.4	13.2	13.3	10.2	12.7	8.7	11.3	6.1	9.9	4.2	8.9	9.2	9.7	21.6	13.3	21.9	12.6	16.6	14.1	16.2	14.0	12.9	12.9
E	17.3	12.1	16.5	13.2	17.3	12.4	22.4	11.4	21.1	11.2	19.9	10.4	13.3	9.8	17.3	9.4	28.1	11.7	25.8	11.6	18.6	12.2	16.9	12.4	19.6	11.5
SE	18.8	12.3	18.3	12.2	25.8	11.9	33.1	12.7	36.7	12.4	34.6	11.2	27.6	9.7	23.7	9.5	18.7	12.1	15.5	11.3	18.7	13.1	17.7	12.4	24.3	11.6
S	12.1	11.2	13.5	11.7	13.3	11.6	11.3	12.0	13.5	10.8	20.2	10.3	25.9	9.6	20.0	9.0	9.0	11.0	5.6	10.9	11.2	12.8	12.2	12.9	14.2	10.8
SW	3.5	10.8	4.5	11.5	3.0	9.3	2.9	9.8	3.4	9.1	4.8	9.2	11.3	8.6	8.5	8.7	2.7	9.0	2.5	9.5	3.7	11.4	4.0	11.2	4.7	9.5
W	5.1	15.1	5.6	12.8	3.9	14.4	3.1	12.2	2.8	9.7	4.1	8.6	7.0	8.6	6.8	8.1	2.6	10.4	2.9	12.0	3.7	12.5	4.3	12.9	4.4	11.1
NW	10.2	16.9	9.2	16.3	7.6	16.4	5.7	15.1	3.5	11.5	2.4	7.2	2.6	8.2	3.8	8.5	3.4	10.0	5.6	14.2	7.1	15.4	8.8	15.9	5.7	14.3
Var	0.0	--	0.0	--	*	2.0	*	2.0	*	2.0	0.1	2.8	*	2.0	*	4.0	*	1.0	*	2.0	0.0	--	0.1	1.0	*	2.2
Calm	--	--	1.8	--	1.9	--	1.7	--	3.3	--	4.3	--	4.8	--	5.3	--	3.2	--	1.9	--	1.6	--	1.2	--	2.8	--
Obs.	3886		3620		4061		3772		4119		4687		4479		4422		4317		4273		3886		3870		49392	

% -- Percentage frequency wind blows <u>from</u> that direction

spd. -- wind speed

* -- less than 0.05%

var -- Variable winds

obs. -- Number of observations

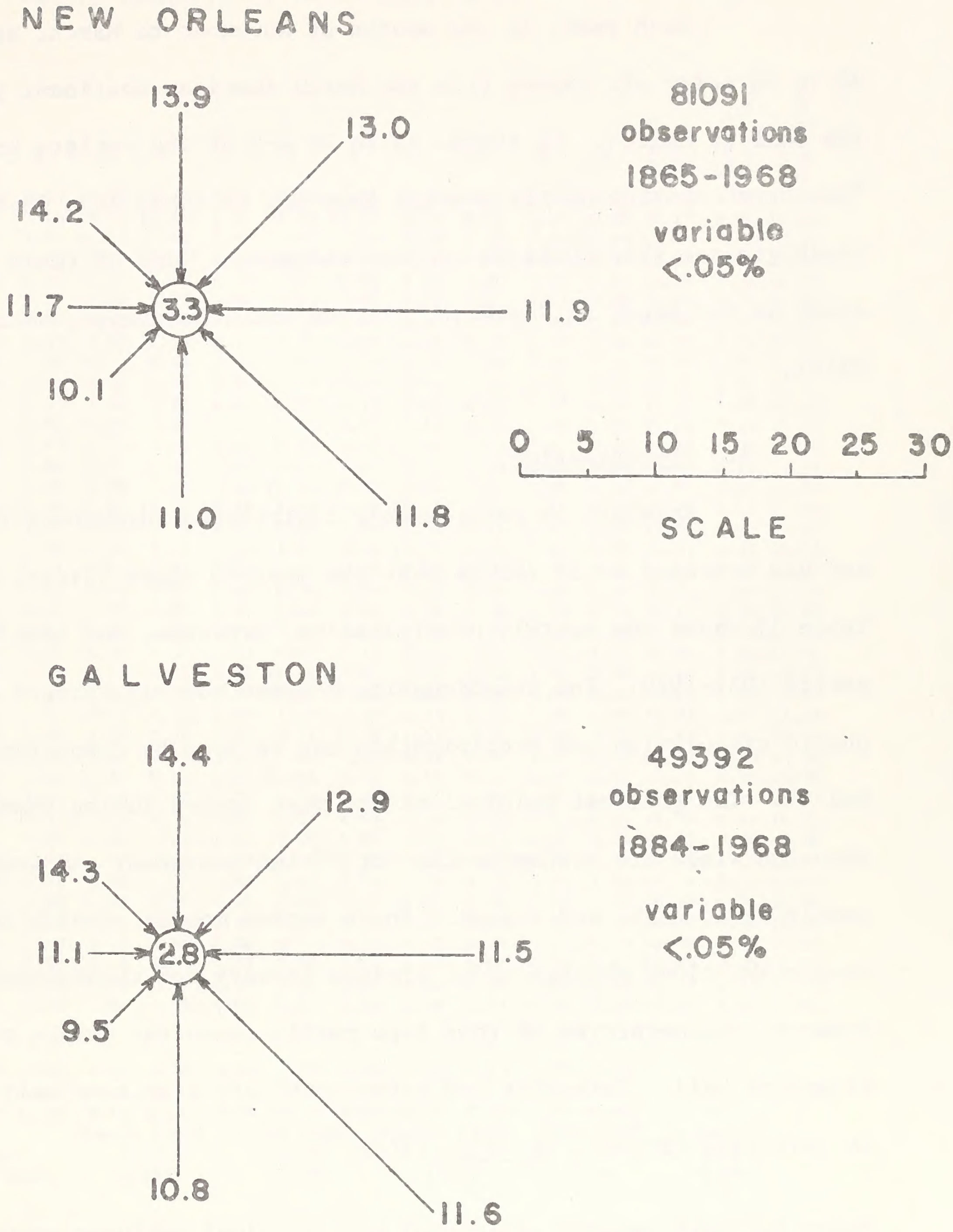


Figure 12. Annual wind patterns from two localities along the northern coast of the Gulf of Mexico. (Data source: U.S. Naval Weather Service Command, 1970 a, b) Numbers at the ends of the arrows indicate average velocity in knots; number at the center is the percentage occurrence of calms. Length of arrows indicate percentage occurrence of winds from that direction.

2. "Northers"

Each year, in the months of November to March, approximately 30 to 40 polar air masses from the North American continent penetrate to the Gulf of Mexico. Of these, 15 to 20 are of the variety known as "northers" lasting on the average from one to three days during which winds greater than 20 knots are not uncommon. Many of these storms reach as far south as Key West, Florida and Tehuantepec, Mexico (Leipper, 1954).

3. Precipitation

Rainfall is faily evenly distributed throughout the year and has averaged 59.20 inches over the last 40 years (Stone, 1972). Table 11 shows the monthly precipitation, averages, and total for the period 1931-1970. The relationships between monthly changes in atmospheric circulation and precipitation can be seen by comparing Tables 5 and 6. The greatest rainfall of the year occurs during those months when the winds are predominantly out of the southeast and south, namely June, July, and August. These warmer months usually have convective cloud systems which produce showers and thunderstorms; however, thunderstorms of this type rarely cause any damage or have attendant hail. Tornadoes and waterspouts are also extremely rare in this area (Brower, et. al., 1972).

Heavy rainfall amounts associated with tropical cyclones account for the high monthly average in September. In October, 1937, a record

Table 6. Monthly precipitation in inches (metric equivalents given). southeast division, 1931-1970. Extracted and derived from National Climatic Summary. (from Stone, 1972)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Annual Total	Annual Mean (In.)	Annual Mean (cm)
1931	4.37	3.79	4.43	2.88	2.35	2.76	8.88	7.52	2.75	6.62	3.31	8.02	57.58	4.81	12.21
1932	5.40	2.64	3.16	5.57	11.26	2.89	5.33	10.65	6.71	8.50	3.21	4.90	70.22	5.85	14.18
1933	4.27	6.27	7.21	6.41	2.45	1.65	6.40	4.18	2.36	2.10	3.74	2.88	49.92	4.16	10.57
1934	6.84	2.91	4.60	2.83	7.98	6.36	4.72	10.77	2.90	4.91	6.00	2.56	63.38	5.28	13.41
1935	1.70	4.97	5.28	6.77	2.68	4.63	7.95	6.66	4.65	.80	1.57	5.92	53.58	4.46	11.33
1936	7.04	5.07	2.71	4.08	5.83	.95	5.98	7.49	4.02	1.75	2.91	3.70	51.53	4.29	10.90
1937	3.96	3.29	6.00	3.78	2.93	6.56	4.53	7.50	5.55	13.89	2.00	3.70	63.69	5.31	13.49
1938	4.82	2.40	1.33	3.79	4.14	5.03	8.21	4.89	4.31	2.13	3.22	3.82	48.09	4.01	10.19
1939	2.09	4.36	.96	2.72	9.46	5.05	7.43	6.79	6.93	.98	6.86	2.74	56.37	4.70	11.94
1940	3.55	8.54	3.53	8.80	1.40	8.50	9.43	10.08	5.81	.47	3.01	8.33	71.45	5.95	15.11
1941	3.56	3.84	4.57	2.10	3.73	8.12	8.10	4.53	7.07	4.63	2.57	4.60	57.42	4.78	12.14
1942	1.87	9.71	6.66	1.93	5.50	11.51	7.74	8.78	7.12	6.25	1.46	4.75	73.28	6.11	15.52
1943	2.72	1.78	7.43	1.71	3.98	5.45	6.85	4.48	14.82	.93	2.8[illegible]	4.20	57.16	4.76	12.10
1944	9.22	4.42	4.60	8.14	4.71	3.22	5.64	7.11	6.21	1.00	10.64	2.54	67.45	5.62	14.27
1945	4.73	4.91	2.40	3.50	3.26	3.53	11.37	8.31	7.00	3.27	1.81	7.12	61.21	5.10	12.10
1946	5.40	3.50	12.24	2.86	10.79	9.86	7.89	4.26	11.55	.56	4.47	3.41	76.79	6.40	16.26
1947	8.37	3.38	7.35	7.52	4.75	4.47	2.88	5.86	4.51	2.11	12.43	7.96	71.59	5.97	15.17
1948	4.95	1.54	13.96	2.30	3.45	2.73	7.19	6.15	14.59	1.21	12.49	4.89	75.45	6.29	15.98
1949	2.17	3.49	9.11	8.93	1.35	5.44	8.47	6.67	8.73	4.29	.39	5.52	64.56	5.38	13.67
1950	2.39	3.15	6.25	6.94	2.74	5.86	8.36	2.95	2.72	2.26	1.00	6.79	51.41	4.26	10.82
1951	3.60	2.20	6.85	6.30	2.70	2.79	6.66	3.65	7.39	1.38	3.43	3.17	50.12	4.18	10.62
1952	2.58	8.98	2.96	5.72	5.42	1.75	7.31	5.96	4.37	.10	2.41	4.98	52.54	4.38	11.13
1953	2.23	6.26	3.78	6.32	1.82	8.03	9.03	7.77	2.07	.53	8.63	11.11	67.58	5.63	14.30
1954	6.36	1.16	1.76	2.14	4.16	3.82	11.24	2.92	7.26	4.22	2.50	5.59	51.11	4.26	10.82
1955	5.35	3.56	.25	4.34	4.08	3.29	9.69	9.60	5.82	2.19	4.08	3.26	55.51	4.63	11.76
1956	3.67	7.17	3.06	3.61	4.32	9.06	7.02	4.80	11.33	2.65	1.50	5.59	63.78	5.31	13.49
1957	1.31	3.34	7.78	7.29	2.96	7.79	5.21	6.58	11.55	2.62	5.83	2.63	64.89	5.41	13.74
1958	7.49	4.64	7.02	2.81	7.65	5.24	9.00	7.73	8.69	2.39	1.44	1.57	65.67	5.47	13.89
1959	3.40	8.80	3.63	4.22	9.17	9.59	11.71	6.52	4.49	9.14	1.44	2.06	74.17	6.18	15.70
1960	4.29	5.20	3.19	5.28	3.77	1.77	5.26	8.77	5.66	5.19	.32	4.29	52.99	4.42	11.23
1961	6.32	7.14	7.35	3.49	4.76	9.49	7.08	8.08	7.32	1.72	7.11	6.42	77.28	6.44	16.36
1962	4.30	1.14	2.07	2.24	.67	6.87	3.99	5.00	4.23	3.03	2.84	3.24	39.62	3.30	8.38
1963	4.17	5.12	.91	.88	2.12	7.59	6.34	3.38	7.08	.04	8.72	5.24	51.59	4.30	11.92
1964	7.73	7.25	5.71	5.06	3.18	4.03	9.96	5.56	3.78	5.78	3.51	2.19	63.74	5.31	13.49
1965	4.97	6.01	3.69	1.01	2.96	4.06	6.58	7.47	9.64	1.18	1.79	7.19	56.55	4.71	11.96
1966	11.22	11.07	1.96	5.97	4.05	7.59	9.14	6.93	6.67	3.28	1.57	6.59	76.04	6.34	16.10
1967	4.31	5.56	2.23	1.77	3.86	4.56	6.71	9.36	5.93	6.06	.28	10.13	60.76	5.06	12.85
1968	1.70	3.24	2.67	3.41	4.73	3.57	5.30	5.02	2.96	1.67	4.26	6.42	44.95	3.75	9.53
1969	3.63	4.13	6.74	6.86	6.99	1.47	8.25	6.22	2.75	1.08	1.02	5.28	53.62	4.47	11.35
1970	3.38	2.22	7.49	.81	5.78	4.06	6.27	8.26	6.66	6.23	1.05	3.02	55.23	4.60	11.68
Monthly Average:	5.89	4.70	4.90	4.31	4.50	5.27	7.37	6.63	6.40	3.23	3.74	4.96			
Monthly Average (cm):	14.96	11.84	12.45	10.95	11.43	13.39	18.72	16.84	16.26	8.20	9.50	12.59			

	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Annual
Seasonal Average:	5.18	4.57	6.42	4.46	5.16
" " (cm):	13.16	11.61	16.31	11.33	13.10

fall of 25 inches was recorded at New Orleans, approximately eight times the normal amount for that month.

Winter rains are associated with the frequent passage of frontal systems through the Louisiana area. Rainfalls are generally slow, steady, and relatively continuous often lasting several days. Snowfalls are rare, and when frozen precipitation does occur it usually melts upon contact with the ground. A glaring exception to this occurred in January of 1973, during which time ice, snow, and freezing rain fell in large amounts on Louisiana and the rest of the southeastern U.S. Incidence of frozen precipitation decreases with distance offshore and rapidly reaches zero.

4. Humidity, Cloudiness and Fog

Humidity along the northern Gulf Coast is high as a result of abundant rainfall and the prevailing southeasterly winds which have a long fetch over the warm waters of the Gulf of Mexico. Table 7 shows the percent frequency of six classes of humidity on a seasonal basis for New Orleans; humidity is generally high all year, but is highest during the summer (U.S. Army Corps of Engineers, 1973).

On the yearly average, cloud cover obscures four- to six-tenths of the sky (Leipper, 1954) with relatively little seasonal variation. October is generally the clearest month while December through March are the cloudiest. Winter days are frequently overcast and gray with

Table 7. Percent frequency of specific relative humidity at selected hours for mid-seasonal months,
From: U.S. Weather Bureau, National Climatic Summary, 1971.
(Stone, 1972)

(New Orleans Records: 1949-1954)

		<30%	<40%	<50%	≥50%	≥70%	≥90%
January	6 am	0	1	2	98	93	61
	3 pm	3	15	23	77	37	7
April	5 am	0	1	2	98	83	53
	3 pm	8	26	43	57	19	7
July	4 am	0	0	0	100	98	77
	3 pm	1	2	17	83	41	6
October	5 am	0	0	3	97	90	52
	3 pm	11	33	47	53	13	4

a dense cloud cover; in summer, however, there are usually only white, cottony cumulus or high, thin cirrus clouds (U.S. Dept. Commerce, 1967).

Fog, like cloudiness, is most likely to appear in the colder months from November through April. It is the result of warm, moist air from the Gulf being blown over the colder continental land mass resulting in precipitation and the formation of dense advection fogs or sea fogs (Orton, 1964). Fog is most frequent in the vicinity of harbor entrances and capes, and will dissipate with northerly winds or strong heating by the sun. Generally, coastal fogs last 3 or 4 hours although particularly dense sea fogs may persist for several days. Visibility offshore Louisiana is reduced to less than three miles on a monthly average of 4.3 percent of the time (see Tables 8 and 9). Poorest visibility conditions occur during winter and early spring when visibility is reduced to less than 3 miles between 7.9-9.6 percent of the time (J. Peake, 1971).

5. Temperature

The air temperature of coastal Louisiana is influenced strongly by the mild temperatures of the surrounding seawater. Average annual air temperatures along the coast range in the middle to lower 70° F. range, while the adjacent seawater annual average temperature is 78° F. (Leipper, 1954). At Sabine Pass, for instance, the monthly mean temperatures range from a low of 60.7° F. in

Table 8. Monthly Occurrence of Fog: Lake Charles and New Orleans, Louisiana (Data from J. Peake, 1971). Expressed in number of days that heavy fog occurred at each station for the given month.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annu.
Station: Lake Charles												
8	2	5	4	3	-	-	1	3	5	-	11	42
Station: New Orleans												
10	2	3	1	1	-	-	-	1	1	-	8	27

Table 9. Visibility Reduction, caused primarily by fog, expressed in percent occurrence (Data from J. Peake, 1971).

Month	Less Than 3 miles	Less Than 1 mile	Less Than 1/2 mile	Less Than 1/4 mile	Less Than 1/8 mile
Jan	7.9	3.3	2.2	1.6	1.4
Feb	9.0	3.9	2.7	2.0	1.7
Mar	9.6	4.2	2.9	2.2	1.9
Apr	8.0	3.4	2.3	1.7	1.5
May	2.9	1.2	0.8	0.6	0.4
Jun	1.0	0.5	0.3	0.2	0.1
Jul	0.7	0.2	0.1	0.1	0.0
Aug	0.8	0.2	0.1	0.1	0.0
Sep	1.0	0.5	0.3	0.2	0.1
Oct	2.0	1.0	0.6	0.4	0.2
Nov	3.3	1.5	1.0	0.7	0.5
Dec	5.7	2.3	1.6	1.2	0.0
Annual	4.3	1.9	1.2	0.9	0.7

January to a high of 84.2° F. in August; the seawater temperature in this area ranges from 64.3° F. in February to 85.5° F. in August. Thus, in most months the warm Gulf waters tend to ameliorate the coastal climate of Louisiana.

Extreme low and high temperatures occur with the intrusion of a continental air mass, for instance, a "norther" in winter. Extreme maritime air temperatures range from a minimum of 29° F. in January to a maximum of 100° F. for each of the summer months (U.S. Army Corps of Engineers, 1973).

Table 10 gives representative monthly averages, ranges, minima, and maxima for selected localities along the North-Central Gulf Coast.

6. Storms

a. Extratropical Cyclones

Extratropical cyclones are low pressure storm systems that develop in the middle or high latitudes which, in the case of the north-central Gulf of Mexico would be over the continental U.S. They are usually associated with the passage of frontal systems, and occur most frequently in winter and spring as "northers". On the average, 15 to 20 of these storms reach the Louisiana coast annually with winds in excess of 33 knots and as great as 65 knots (U.S. Army Corps of Engineers, 1973). These storms rapidly dissipate, or move on, after moving out over the Gulf of Mexico.

PORT ARTHUR, TEXAS

Month	Air temperature (°F.) Normal Daily maximum	Normal Daily minimum	Normal Monthly	Extreme Record highest	Extreme Record lowest
(a)	(b)	(b)	(b)	6	6
Jan.	63.5	43.7	53.6	80	14
Feb.	65.8	46.2	56.0	84	25
Mar.	71.3	50.8	61.1	84	27
Apr.	78.0	58.3	68.2	90	37
May	83.8	65.6	74.7	92	49
June	89.6	71.5	80.6	99	60
July	91.0	72.7	81.9	100	69
Aug.	91.2	73.3	82.3	107	64
Sept.	88.4	63.0	78.2	99	54
Oct.	81.7	58.8	70.3	95	37
Nov.	70.7	43.6	59.7	87	30
Dec.	64.9	44.6	54.8	81	17
Year	78.3	58.5	68.5	107	14

GALVESTON, TEXAS

Month	Air temperature (°F.) Normal Daily maximum	Normal Daily minimum	Normal Monthly	Extreme Record highest	Extreme Record lowest
(a)	(b)	(b)	(b)	96	96
Jan.	60.5	49.3	54.9	76	11
Feb.	62.4	51.2	56.8	83	8
Mar.	66.6	56.2	61.4	85	27
Apr.	73.0	64.0	68.5	92	38
May	80.1	71.5	75.8	93	52
June	85.6	77.7	81.7	99	57
July	87.3	78.9	83.1	101	66
Aug.	87.5	79.0	83.3	100	67
Sept.	84.6	75.5	80.1	96	52
Oct.	78.5	68.4	73.5	94	41
Nov.	68.6	57.4	63.0	85	26
Dec.	62.7	51.6	57.2	80	18
Year	74.8	65.1	69.9	101	8

NEW ORLEANS, LOUISIANA

Month	Air temperature (°F.) Normal Daily maximum	Normal Daily minimum	Normal Monthly	Extreme Record highest	Extreme Record lowest
(a)	(b)	(b)	(b)	20	20
Jan.	64.4	44.8	54.6	83	14
Feb.	66.7	47.5	57.1	84	19
Mar.	71.2	51.6	61.4	87	29
Apr.	77.7	58.1	67.9	91	38
May	84.4	64.4	74.4	96	41
June	89.6	70.5	80.1	100	55
July	90.6	72.6	81.6	99	65
Aug.	90.7	73.0	81.9	100	62
Sept.	87.2	69.3	78.3	97	54
Oct.	80.3	60.5	70.4	92	36
Nov.	70.3	49.6	60.0	86	28
Dec.	65.3	45.5	55.4	83	17
Year	78.2	59.0	68.6	100	14

MOBILE, ALABAMA

Month	Air temperature (°F.) Normal Daily maximum	Normal Daily minimum	Normal Monthly	Extreme Record highest	Extreme Record lowest
(a)	(b)	(b)	(b)	5	5
Jan.	62.3	43.7	53.0	76	8
Feb.	64.7	45.7	55.2	79	11
Mar.	70.3	50.3	60.3	87	11
Apr.	77.5	57.6	67.6	90	38
May	85.9	65.3	75.6	99	52
June	91.4	71.5	81.5	100	56
July	92.0	73.1	82.6	99	69
Aug.	91.2	73.0	82.1	98	66
Sept.	87.4	68.3	77.9	98	54
Oct.	80.3	59.5	69.9	93	39
Nov.	69.6	48.2	58.9	81	26
Dec.	63.9	44.3	54.1	78	10
Year	78.0	58.4	68.2	100	8

Table 10. Air temperature means and extremes from several coastal localities. (From U.S. Department of Commerce, 1967)

Preferred storm tracks over the Gulf of Mexico are shown in Fig. 15 these tracks give the preferred areas of formation and direction of movement of extratropical cyclones in winter. It is obvious that such storms form in other areas, during other seasons, and follow different tracks from those indicated; however, it is noteworthy that these tracks are frequent paths for extratropical storms and approximate the southernmost position of continental frontal systems.

More general information on the seasonal frequency and intensity of these storms is presented in Table 11. These statistics show that low pressure centers are quite frequent in the winter and that few of these storms have pressures as low as 1000 mb.

Table 11. Seasonal distribution (total number of cases) of intensity of low pressure centers (measured by minimum sea level pressure in millibars) over Gulf of Mexico during the 1954-1969 period (From Jordan, 1973).

	1000 mb	1000-1004 mb	1005-1009 mb	1010 mb	Total
Winter	4	11	20	35	70
Spring	1	8	16	11	36
Summar	1	4	3	19	27
Fall	3	7	13	23	46
Total	9	30	52	88	179

b. Tropical Cyclones

Tropical cyclones are low pressure storm systems that have their origin over the warm tropical waters of the central Atlantic Ocean, Caribbean Sea, or southeastern Gulf of Mexico. They, by definition, must have winds in excess of 34 knots, and if the winds exceed 64 knots they are considered hurricanes. Tropical cyclones occur most frequently between June and late October (Brower, 1972) and there is a relatively high probability that a tropical cyclone will land in Louisiana (see Fig. 14). Statistics for hurricanes and tropical cyclones are often lumped together since it is often difficult, especially in the older records, to determine the storm intensity while at sea. The probability of a tropical cyclone or hurricane influencing the north-central Gulf Coast during any given year is given in Fig. 14; this figure shows that the chances are 1 in 6 that a tropical cyclone will land somewhere along the coast of Louisiana in any one year. Fig. 11 shows the earliest and latest occurrence of tropical cyclones for the period 1886-1970 (all data from Stone, 1972).

Most hurricanes and tropical cyclones influencing the Gulf of Mexico form in the eastern Caribbean or the central Atlantic Ocean and there is adequate advance warning, often as long as several days, of the impending danger. There is no preferred approach route as can be seen from the hurricane tracks plotted in Fig. 13, although early

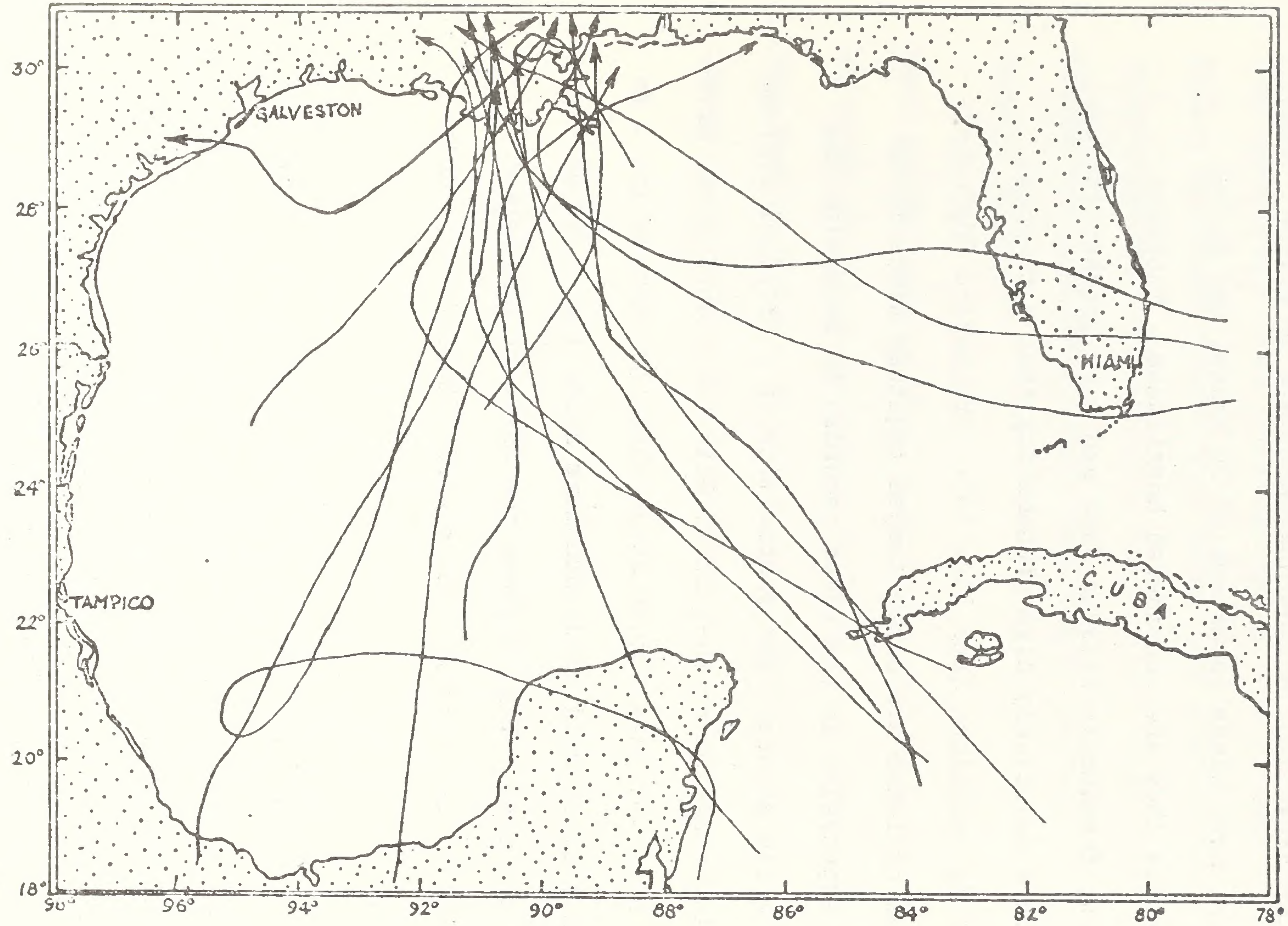
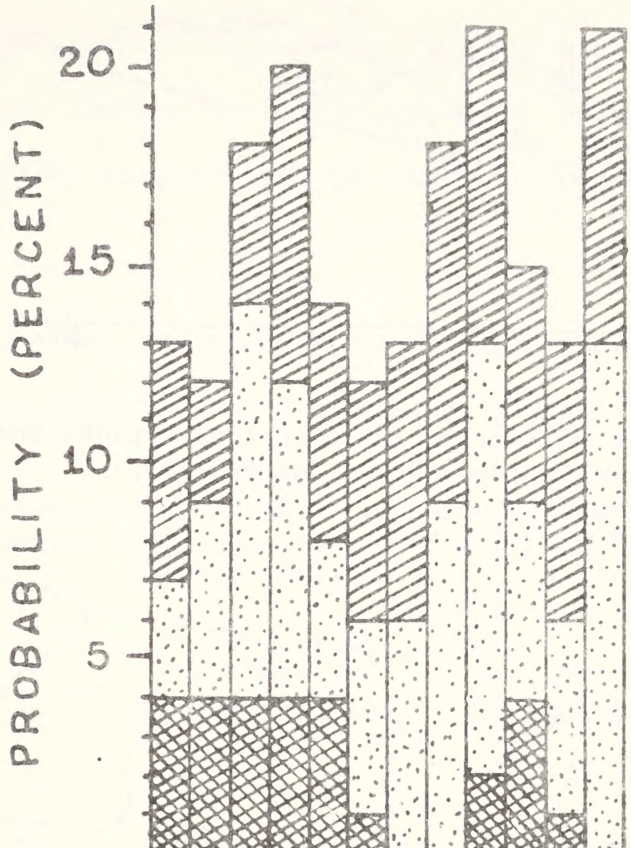


Figure 13. Hurricane tracks for those storms striking the Louisiana coast (Data from U.S. Department of Commerce, 1965 and supplements).



COASTAL SECTOR	3	4	5	6	7	8	9	10	11	12	13	14
ALL TROPICAL CYCLONES	13	12	18	20	14	12	13	18	21	15	13	21
ALL HURRICANES	7	9	14	12	8	6	6	9	13	9	6	11
GREAT HURRICANES	4	4	4	4	4	1	–	–	2	4	1	–

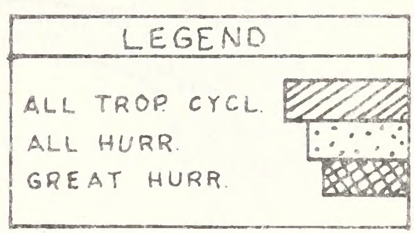


Figure 14. Cyclone probabilities for coastal sectors along the Gulf Coast (From Simpson and Lawrence, 1971). See Figure for location of indicated coastal sectors. The authors used the following groupings of cyclones:
All tropical cyclones have winds 40 mph or higher,
All hurricanes have winds 74 mph or higher,
All great hurricanes have winds 125 mph or higher.

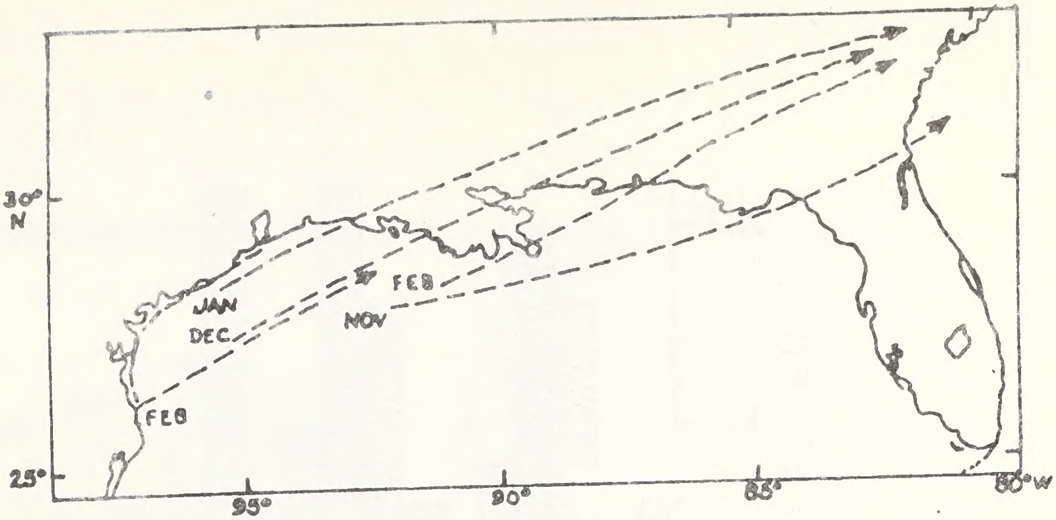


Figure 15. Preferred extratropical cyclone tracks over the Gulf of Mexico. (From Jordan, 1972)

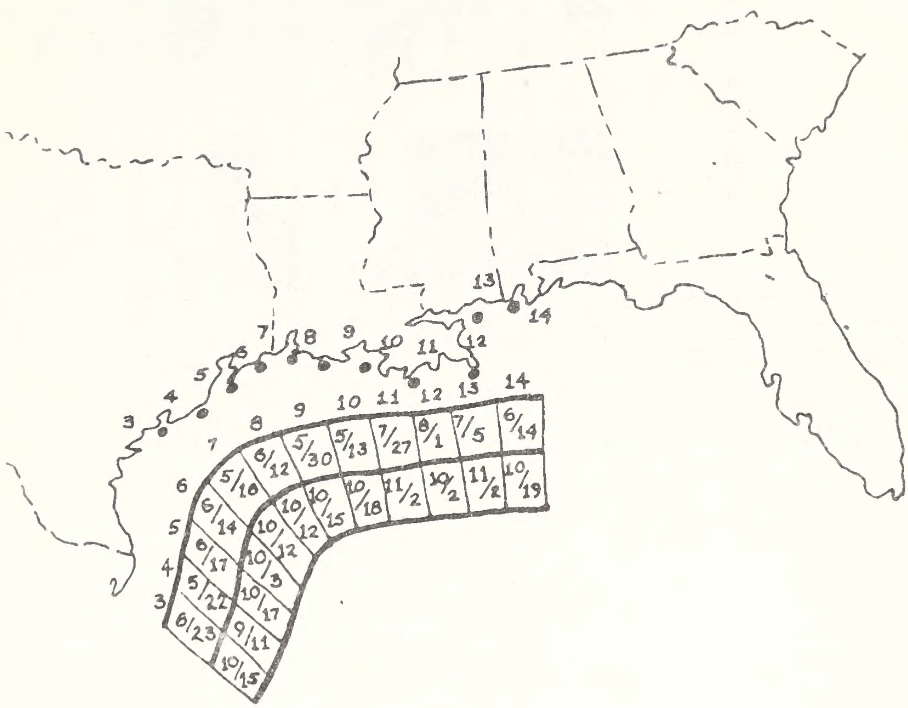


Figure 16. Earliest and latest tropical cyclone occurrences for the period 1886-1970. Numbers within boxes are the month and day of earliest and latest windfalls for the indicated coastal segment (From Simpson and Lawrence, 1971).

season cyclones approach generally from the southeast while later ones are more out of the south. In spite of the fact that most hurricanes form in the tropical ocean areas, a few are generated in the Gulf of Mexico. During the period 1901-1971, seven hurricanes and seven tropical storms formed in the Gulf north of 25° N and east of 85° W.

The data in Table 12 shows occurrences of tropical cyclones and hurricanes for three selected locations along the Louisiana coast.

Table 12. Occurrence of tropical cyclones and hurricanes for selected Louisiana coastal sites (Data from Brower, 1972).

	Total No. 1899-1971	Avg. No. of Years Between Occurrences
Sabine Pass Area		
Tropical Cyclones 1/	32	2.3
Hurricanes 2/	15	4.9
Bayou Lafourche Area		
Tropical Cyclones	45	1.6
Hurricanes	18	4.1
Southwest Pass Area		
Tropical Cyclones	49	1.5
Hurricanes	18	4.1

1/ Tropical cyclones are storms whose winds are equal to, or greater than 34 knots.

2/ Hurricanes are tropical cyclones whose winds are equal to, or greater than 64 knots.

Damage from hurricanes results from high winds and, particularly in the coastal areas, the storm surge 1/ or storm tide which is an abnormally high rise in the water level. Maximum surge height at any location is dependent on many factors including bottom topography, coastline configuration, and storm intensity. The storm surge at Pass Christian, Mississippi associated with hurricane "Camille" in 1969 was 25 feet, and that associated with "Betsy" in 1965 reached nearly 20 feet at Bayou Lafourche (U.S. Army Corps of Engineers, 1970).

The most severe hurricane in recent Gulf history was Hurricane "Camille". On August 17, 1969, she passed along the eastern bank of the Mississippi Delta of Louisiana and into the Mississippi Gulf Coast. 2/ Camille's top winds were estimated at 201.5 miles per hour, and the barometric pressure in her calm eye dropped as low as 26.61 inches of mercury. The hurricane surge at Pass Christian, Mississippi, was recorded at 22.6 feet above the normal level of the Gulf. Offshore installations in areas near South Pass, Main Pass, and Breton Sound were badly damaged. Prior to arrival of the storm, the Offshore Operators Committee advised tapering off production operations, and before the storm hit, 4,000 wells in State and

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1/ A storm surge is a rise above normal water level on the open coast due to the action of wind on the water surface. In essence, a "piling-up" of the water.

2/ Corps of Engineers, Report on Hurricane Camille. Report No. 1338, 1970, U.S. Army Engineer District, New Orleans, Louisiana.

Federal waters were shut-in and 3,000 workmen evacuated. Because of this caution, no injuries to petroleum production personnel were reported and there was a total absence of blowing wells and few leaking wells. The U.S. Geological Survey reported no oil slicks in Federal waters and only one in State waters.

During the onslaught of "Camille", one production platform was destroyed and two were damaged, two drilling rigs were destroyed, and three were damaged. Also in the area were seven drilling rigs that were not damaged. Total damages to the petroleum industry caused by "Camille" were estimated at $71.2 million, breakdown as follows: 1/

Damage to fixed property (onshore)	$26,550,000
Damage to fixed property (offshore)	31,350,000
Damage to movable property	3,750,000
Other expenses (cleanup, evacuation, salaries	3,650,000
Loss of Production	5,900,000
Total Losses	$71,200,000

When the Weather Bureau advises that a hurricane or serious tropical storm is imminent, all oil and gas facilities in,or adjacent to,the path of the storm are evacuated. Upon evacuation, all surface equipment and wellhead controls are shut-in. In addition, blank tubing plugs are set in as many wells as possible to further reduce the possibility of pollution in the event the well is damaged. These tubing plugs form a seal against fluid flow.

1/ Ibid.

Industry is continually conducting research into ways to improve the strength and design of offshore structures. Some of the most recent projects are outlined below.

1. Continental Oil Company's Platform Instrumentation Program consists of a platform in Eugene Island Block 266-F which was instrumented with 126 strain gauges almost three years ago. These strain gauges (100 of which are still operational) were placed on critical joints, structural members, and below the mudline on one piling. Additionally, the platform was outfitted to obtain wind, wave, current, and barometric pressure data. Wave force information as a function of wave height was obtained directly by a transducer. The information is automatically fed into an on-site computer which is programmed to determine stress as a function of the other parameters. Since there is particular interest in storm related stresses, it is noteworthy that the system is so automated that it could function even if the platform is abandoned due to severe weather. While the information gathered thus far is proprietary (potential users may buy into the program), we have been told that the information is now being used for design modifications.

2. Another project, the Joint Industry Wave Force Project (JIWFP), is chaired by Amoco and includes most of the major oil companies. It has as its objective the collection and analysis of wave data in order to permit forecasting of drag and mass coefficients. This

project is being conducted by Professor Robert Dean of the University of Florida at Gainesville.

3. Chevron Oil Company has proposed a cooperative study with eight other companies, to examine the axial load on deep pilings. Axial load refers to two properties; 1) downward or supportive force as a function of the depth of the piling, and 2) the pull-out capacity (or resistance to pulling out) as a function of depth and sediment properties.

4. Chevron has another project to investigate lateral load on pilings, which can be described as an attempt to evaluate how close one piling can be placed to another before the other recognizes its presence (through sediment translated pressures).

5. Shell Oil and eight or nine other companies are sponsoring the Ocean Data Gathering Project (ODGP). Six separate platforms on the Texas and Louisiana OCS were instrumented to measure winds, barometric pressure, and wave heights (but not currents or wave forces) for two years. The data gathering has been completed, and is presently being analyzed and hindcast.

C. Physical Oceanography

1. Surface Circulation

Surface circulation within the Gulf of Mexico is controlled by the Yucatan Current, which enters the area from the Caribbean through the Yucatan Straits. The main flow continues northward towards the Mississippi River delta, where it bifurcates into eastward and westward-flowing branches (Chew, et al., 1962). The eastward flow develops into a clockwise gyre known as the Eastern Gulf Loop Current, and eventually exits the area through the Straits of Florida. Current patterns in the western Gulf are not as clearly defined, however the general circulation consits of a large clockwise gyre generated from the Yucatan Current in the west-central and southern Gulf, and a counter-clockwise northern coastal flow - the westward branch of the bifurcating Yucatan trunk flow (see Figures 17 and 18).

Overall Gulf circulation patterns are fairly well defined during the winter months, but become less so during late spring and summer when the Yucatan Current attains its greatest velocity and volume (Nowlin, 1971). This increased flow is accompanied by the generation of numerous eddies which are frequently transient and poorly delineated, especially in the western Gulf. Nowlin, et al. (1968) described the presence of a large detached eddy in the east-central Gulf during June, 1966 and 1967, just north of the main Loop Current. While in existence, the eddy circulated clockwise with core velocities of 2-3 knots; it migrated slowly westward and ultimately decayed.

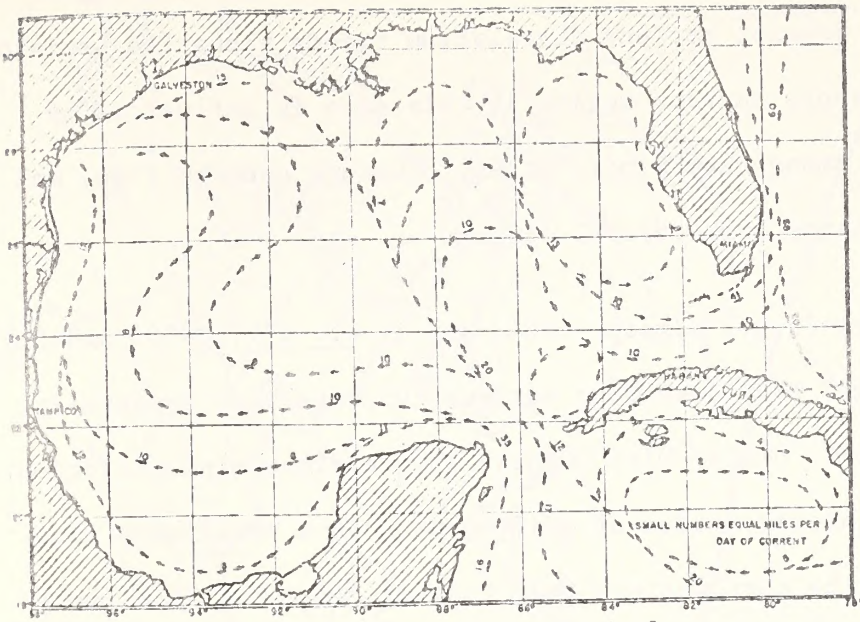

Figure 17 Surface currents in the Gulf of Mexico in June (From Leipper, 1954).

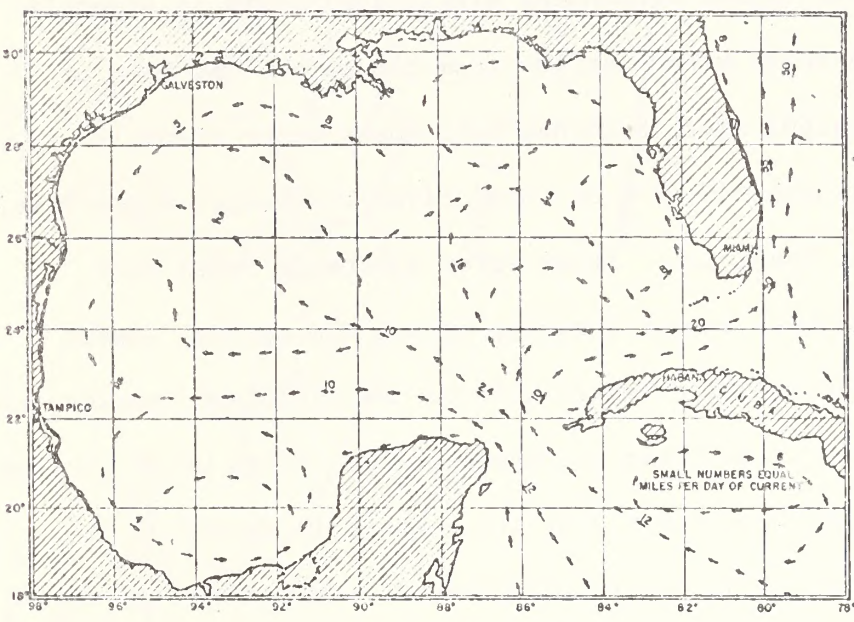

Figure 18 Surface currents in the Gulf of Mexico in December (From Leipper, 1954).

Figure 19 depicts general surface circulation trends along the Louisiana coast. The nearshore current regime in this area is influenced by several factors, among them winds, tides, offshore current flow, and fresh water discharge from coastal rivers.

Many investigators (e.g., Kimsey, 1964; Murray <u>et. al.</u>, 1970; and Scruton, 1956) have observed that nearshore surface currents vary seasonally (and to some extent, daily) with changes in prevalent wind direction. Kimsey's (1964) interpretation of drift bottle data revealed a late-July reversal of the northwestern Gulf coastal current. This change was attributed to strong prevailing southerly winds, and persisted only a few weeks.

The surface current regime around the Mississippi Delta is strongly influenced by the fresh water outflow from the river. At Head of Passes the Mississippi River branches into three major channels: Pass-a-Loutre, transporting 37% of total river discharge; South Pass, 29%; and Southwest Pass, 15%. Fresh water discharge rates vary seasonally with highest values occuring during the spring, lowest in the fall. In addition, climatic effects can introduce considerable short-term variability in these discharge rates. Fresh water outflow from the Mississippi Delta maintains its general integrity as it passes over the more dense, saline underlayer. This discharge tends to create a fresh water "barrier" that could retard or prevent the movement of surface oil into the major pass areas of the Delta. The

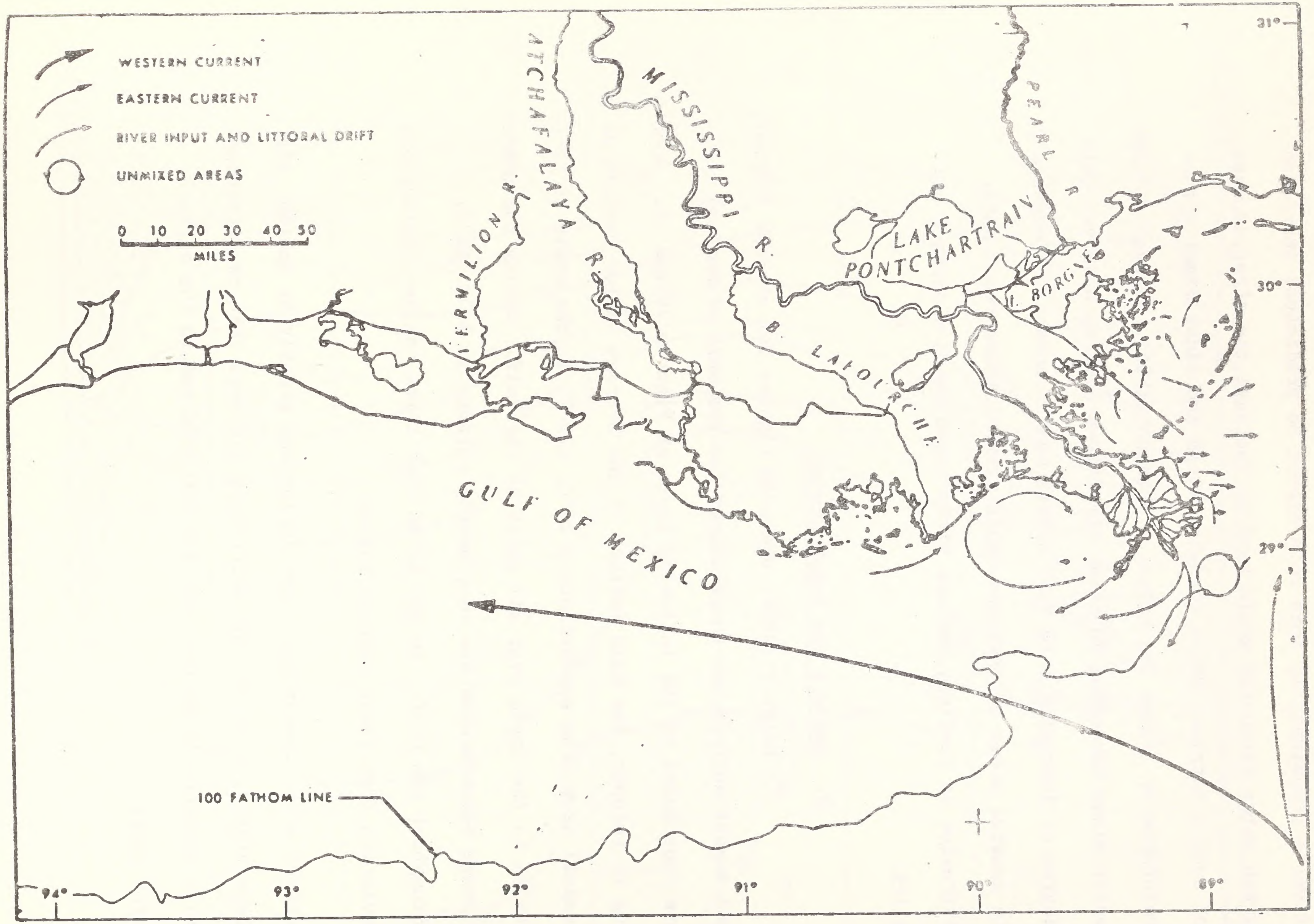

Figure 19. Generalized surface circulation along the Louisiana continental shelf. (From Stone, 1972)

River's competency in this role cannot be predicted; increased fresh water discharge would tend to increase the effectiveness of such a barrier, while changing winds and tides might either reinforce or lessen its effect. Scruton (1956) observed a fresh water plume extending 20 miles off Pass-a-Loutre, however this degree of intrusion into Gulf waters may be unusual. Conversely, in coastal areas between the major passes, where fresh water intrusion is limited, onshore winds could beach a surface oil slick.

2. Surface Sea Temperatures

Leipper (1954) presents figures for average February and August surface sea temperatures for the Gulf of Mexico; they are reproduced on the following pages as Figures 20 and 21. According to Leipper, the main feature of the average winter pattern is a gradual drop from approximately 24°C. (75°F) in the south to 18°C (65°F) in the north over all parts of the Gulf. During the summer, average temperatures are very nearly uniform at 29°C (84°F) throughout the Gulf. In any given year there can be considerable deviation from these average values.

Surface water temperatures are influenced greatly by ambient air temperatures, however the short-term extremes that characterize daily atmospheric heat values are not observed in the surface water layer.

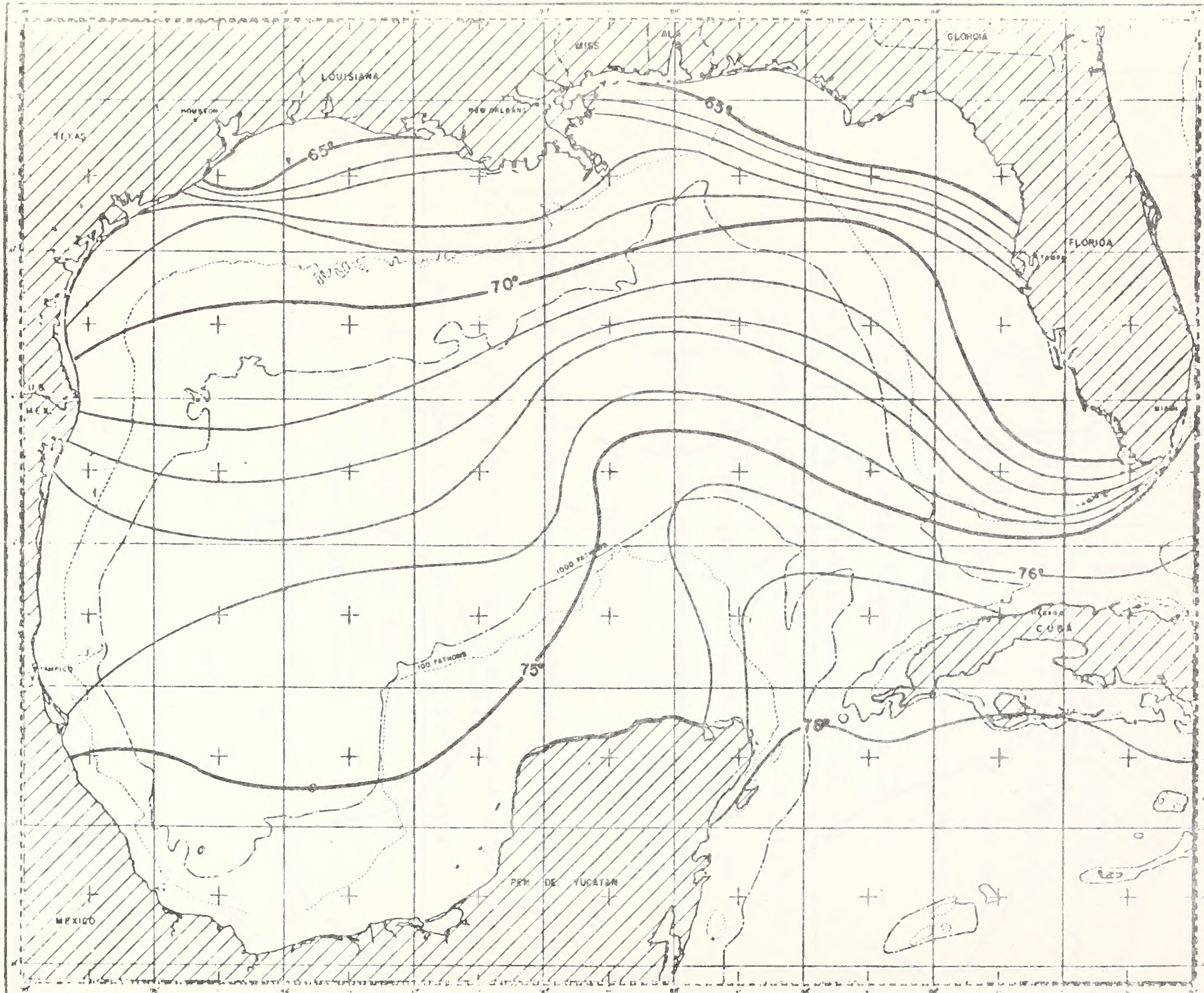

Figure 20. Average sea surface temperatures (F) for February. (from Leipper, 1954; after Fuglister, 1947)

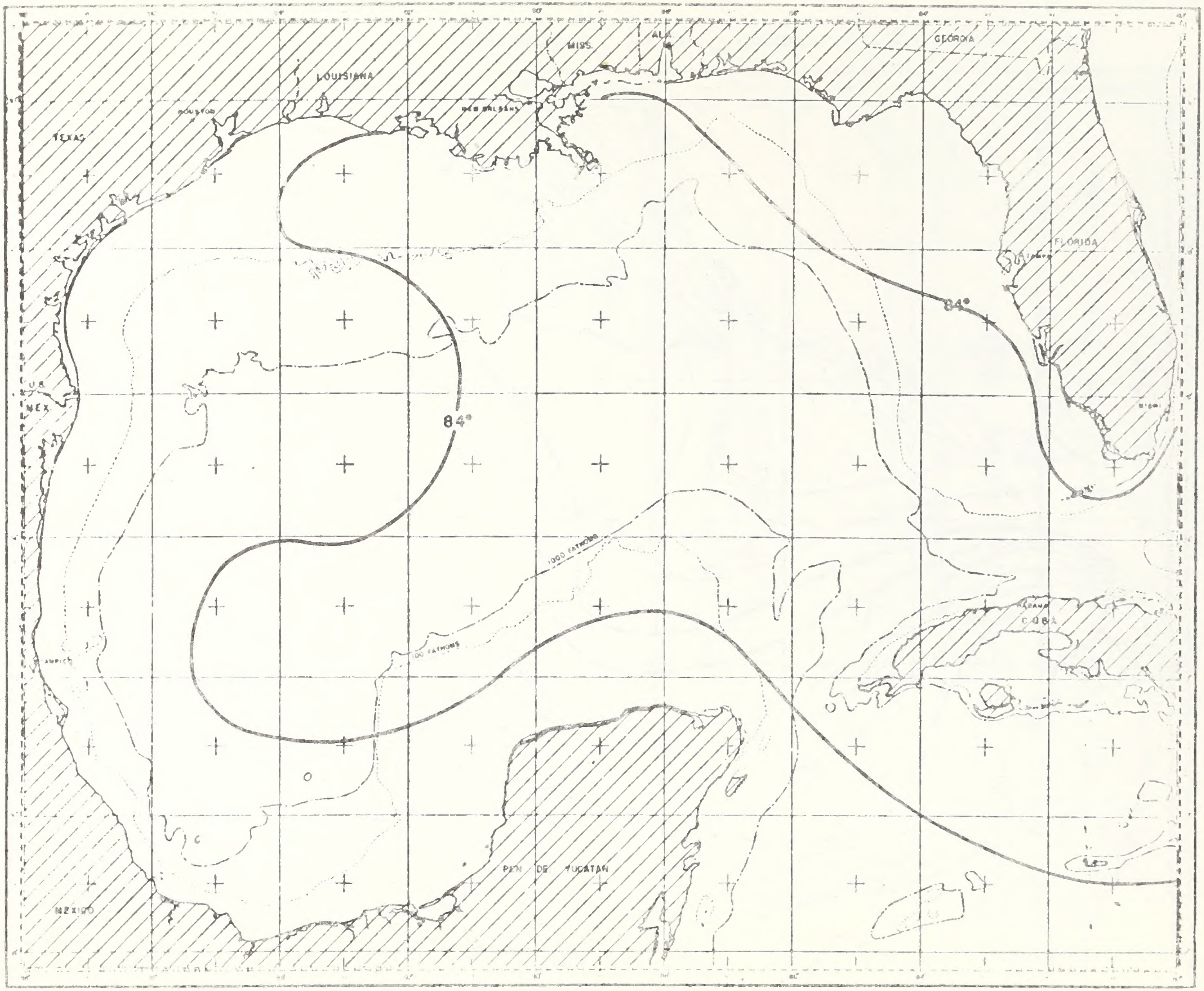

Figure 21. Average sea surface temperatures (F) for August. (from Leipper, 1954; after Fuglister, 1947)

3. Salinity

In the upper 50 meters (168 ft.), water in the central Gulf of Mexico typically has a salinity of very near 36.0 parts per thousand (ppt) (Leipper, 1954, Nowlin, 1972). The distribution of surface salinities during the winter of 1962 is given in Fig.22. This figure clearly reveals the effects of continental fresh water runoff, in lower salinity values over the northern continental shelf. The presence of the northward-flowing Yucatan Current can also be inferred from the salinity data. A similar pattern, but with generally higher salinities due to high evaporation rates, is found for summer conditions. In the eastern Gulf these distributions are modified by the seasonally dependent Loop Current (Sackett, 1972).

4. Tides

Tidal action in the north-central Gulf is predominantly diurnal (one high and one low per day) with extreme values occurring about every two weeks (Stone, 1972). The mean daily tidal range for this area is relatively small, varying between 2" and 24" (U.S. Army Corps of Engineers, 1973); highest mean values occur during September and October while lowest values are observed December through March.

Murray (1972), reporting late March, 1970 observations at a current station east of the Mississippi River delta, measured a maximum total current velocity of 15 cm. sec^{-1}. At this flow rate, tidal action can be expected to make a minor contribution to the flushing of coastal embayments.

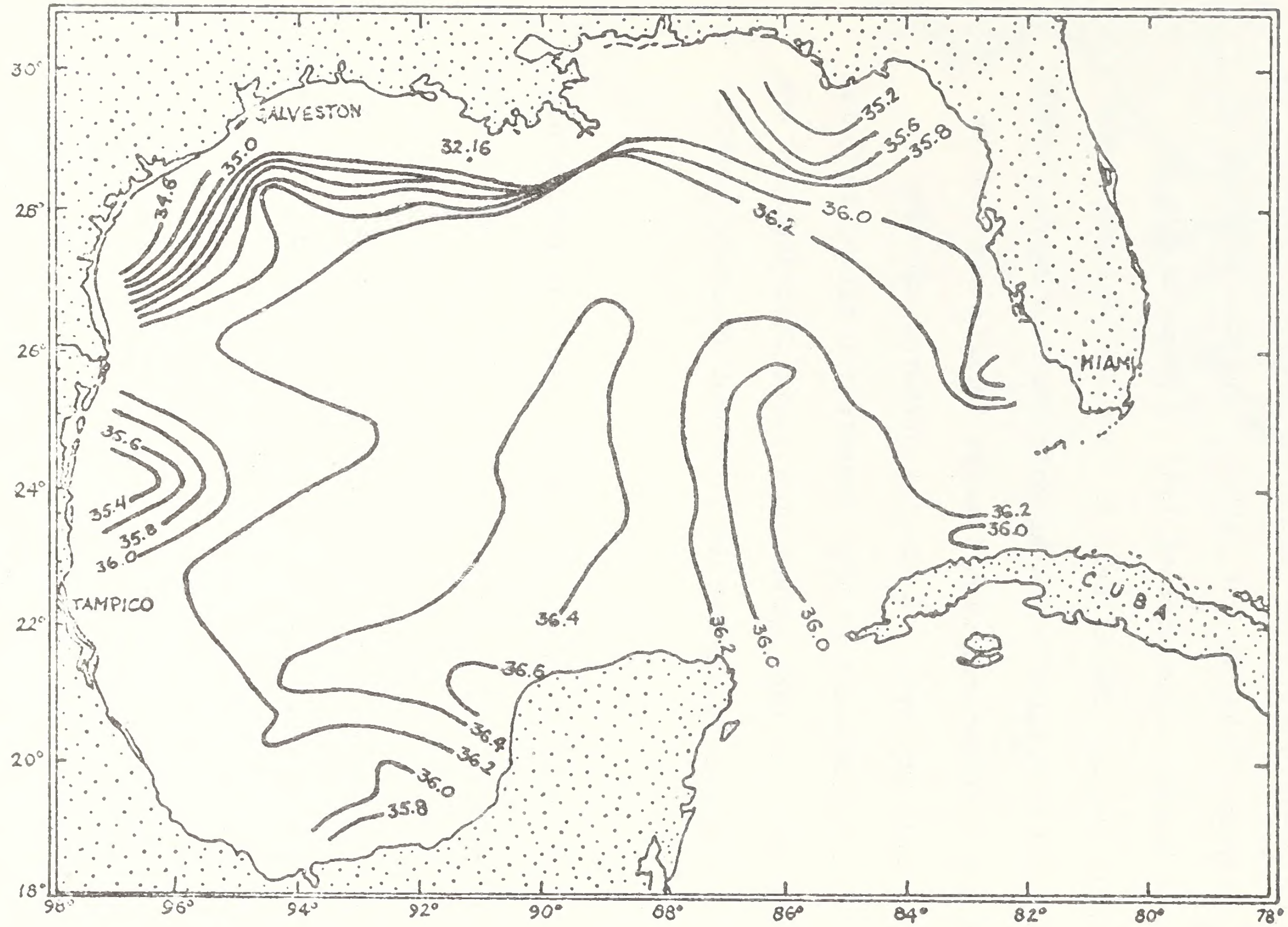

Figure 22. Surface salinities, winter, 1962. All values expressed in parts per thousand (From Nowlin, 1970).

5. Sea State

The Louisiana coastal zone is characterized by a low energy wave regime. Both wind-driven waves and swell are appreciably lower here than along either the Atlantic or Pacific coasts. Tables 13 through 18 give cumulative wave data for three selected onshore sites and one offshore location; data for selected months along with annual values comprise Tables 16 through 21.

Variations in the tabulated wave characteristics can be related to specific wind factors. Thus, the data for July and September reflect the strong influence of southerly winds associated with the circulation around the Bermuda High. A shift to more northerly and northeasterly wave origin accompanies the onset of a winter wind regime dominated by continental cold air masses. Stone (1972) reports that wave power along the Louisiana coast during autumn and winter exceeds that during spring and summer by a factor of 2 to 3. In general, waves originating from the northeast and southeast appear to generate greater wave heights than those from other directions.

AREA: Sabine Pass — CENTRAL POSITION: 28° 35'N 93° 51'W

ENVIRONMENTAL FACTORS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
WAVES (FEET)													
01% ≤	1	1	1	1	1	1	1	1	1	1	1	1	1
05% ≤	1	1	1	1	1	1	1	1	1	1	1	1	1
25% ≤	2	2	2	2	1	1	1	1	1	1	2	2	1
50% ≤	4	4	4	3	3	2	2	2	3	3	4	4	3
75% ≤	6	6	5	5	4	4	3	4	5	5	6	6	5
95% ≤	9	9	8	7	7	6	6	6	7	7	9	9	7
99% ≤	13	12	12	10	10	8	8	7	12	10	12	12	10
Maximum observed	25	21	25	21	15	28	13	16	23	21	26	20	28
Mean	4	4	4	3	3	3	2	2	3	3	4	4	3
≥ 5 Feet (% freq.)	36.2	36.3	34.4	31.5	24.0	17.1	15.1	12.4	26.1	28.6	37.1	36.3	27.7
≥ 8 Feet (% freq.)	7.7	8.6	6.4	4.0	3.3	2.3	1.2	1.0	4.6	4.7	8.4	7.8	5.1
≥ 12 Feet (% freq.)	1.9	2.3	1.3	0.6	0.5	0.4	0.3	0.2	1.2	0.8	1.5	1.8	1.2
≥ 20 Feet (% freq.)	0.1	+	+	0.1	0.0	+	0.0	0.0	0.1	0.2	0.2	+	+

AREA: Bayou Lafourche — CENTRAL POSITION: 28° 49'N 90° 04'W

ENVIRONMENTAL FACTORS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
WAVES (FEET)													
01% ≤	1	1	1	1	1	1	1	1	1	1	1	1	1
05% ≤	1	1	1	1	1	1	1	1	1	1	1	1	1
25% ≤	2	2	2	2	1	1	1	1	1	1	2	2	1
50% ≤	4	4	4	4	3	2	2	2	3	3	4	4	3
75% ≤	6	6	6	5	4	4	3	3	5	5	6	6	5
95% ≤	9	9	9	8	7	6	6	6	8	7	9	9	8
99% ≤	13	13	13	12	10	8	8	7	12	10	12	12	12
Maximum observed	25	23	21	16	13	21	13	13	31	18	25	20	31
Mean	4	4	4	4	3	2	2	2	3	3	4	4	3
≥ 5 Feet (% freq.)	37.4	39.1	38.7	33.9	22.9	14.3	8.6	11.5	27.0	28.6	35.7	37.5	28.0
≥ 8 Feet (% freq.)	8.0	9.3	8.7	6.1	3.5	1.3	1.1	1.0	6.2	4.6	7.5	8.5	5.5
≥ 12 Feet (% freq.)	2.2	2.9	2.0	1.1	0.5	0.3	0.2	0.2	1.6	0.6	1.9	1.8	1.3
≥ 20 Feet (% freq.)	0.1	0.1	0.1	0.0	0.0	+	0.0	0.0	0.2	0.0	0.1	0.1	0.1

AREA: Southwest Pass — CENTRAL POSITION: 28 56'N 89° 29'W

ENVIRONMENTAL FACTORS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
WAVES (FEET)													
01% ≤	1	1	1	1	1	1	1	1	1	1	1	1	1
05% ≤	1	1	1	1	1	1	1	1	1	1	1	1	1
25% ≤	2	2	2	2	1	1	1	1	1	2	2	2	1
50% ≤	4	4	4	3	2	2	2	2	3	3	4	4	3
75% ≤	6	6	6	5	4	4	3	3	5	6	5	6	5
95% ≤	9	9	9	7	6	6	6	6	8	8	8	9	8
99% ≤	13	15	13	10	8	8	8	13	13	12	12	12	10
Maximum observed	23	31	21	15	13	21	12	21	31	20	20	21	31
Mean	4	4	4	3	3	2	2	2	3	4	4	4	3
≥ 5 Feet (% freq.)	39.5	39.7	35.3	29.6	17.4	11.9	8.4	11.6	25.6	32.7	36.8	37.2	27.4
≥ 8 Feet (% freq.)	10.1	9.6	8.8	4.5	2.3	1.6	0.9	1.5	7.2	7.3	7.5	8.6	5.8
≥ 12 Feet (% freq.)	2.4	2.9	1.8	0.6	0.4	0.5	0.1	0.5	2.4	1.2	1.7	1.8	1.3
≥ 20 Feet (% freq.)	0.2	0.3	0.2	0.0	0.0	0.1	0.0	0.1	0.2	+	0.1	+	0.1

Tables 13, 14, 15 - Cumulative wave data for Sabine Pass, Bayou Lafourche, and Southwest Pass, Louisiana (From Stone, 1972)

Table 16 Average percentage frequency of occurrence of significant wave height-direction groups: Grand Isle Block 46: Offshore Louisiana: 110 foot mean low water depth: Annual (From Glenn, 1972).

Direction	Significant Wave Height Groups (ft.) 0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	10-15	15+	Total
N	1.5	2.7	2.1	1.5	0.7	0.2	0.0	8.7
NE	2.9	5.8	4.6	2.9	1.2	0.5	0.1	18.0
E	2.5	5.2	4.1	2.7	1.4	1.1	0.3	17.3
SE	2.5	5.3	5.4	3.9	2.0	1.7	0.3	21.1
S	2.1	4.5	3.6	2.3	1.1	0.7	0.2	14.5
SW	1.9	3.5	1.8	1.0	0.5	0.2	0.0	8.9
W	1.6	2.3	1.1	0.6	0.2	0.1	0.0	5.9
NW	1.7	2.1	1.1	0.5	0.2	0.0	0.0	5.6
TOTAL	16.7	31.4	23.8	15.4	7.3	4.5	0.9	100.0

Table 17 Average percentage frequency of occurrence of significant wave height-direction groups: Grand Isle Block 46: Offshore Louisiana: 110 foot mean low water depth: April (From Glenn, 1972).

Direction	Significant Wave Height Groups (ft.) 0-1.9	2-3.9	4-5.9	6-7.9	3-9.9	10-15	15+	Total
N	1.0	2.0	1.8	1.2	0.4	0.1	0.0	6.5
NE	1.6	4.7	3.3	1.7	0.4	0.1	0.0	11.8
E	1.9	3.8	3.6	2.3	0.8	0.3	0.1	12.8
SE	3.3	6.3	10.6	6.7	3.6	1.9	0.2	32.6
S	2.0	4.8	6.5	4.4	2.1	1.1	0.1	21.0
SW	0.8	1.5	1.7	1.2	0.4	0.2	0.0	5.8
W	0.7	1.4	1.1	0.7	0.2	0.1	0.0	4.2
NW	1.3	2.4	1.1	0.4	0.1	0.0	0.0	5.3
TOTAL	12.6	26.9	29.7	18.6	8.0	3.8	0.4	100.0

Table 18 Average percentage frequency of occurrence of significant wave height-direction groups: Grand Isle Block 46: Offshore Louisiana: 110 foot mean low water depth: July (From Glenn, 1972).

Direction	Significant Wave Height Groups (ft.) 0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	10-15	15+	Total
N	1.1	0.7	0.2	0.0	0.0	0.0	0.0	2.0
NE	1.2	1.3	0.4	0.1	0.0	0.0	0.0	3.0
E	2.8	2.9	1.1	0.3	0.1	0.0	0.0	7.2
SE	4.9	8.9	2.9	1.0	0.3	0.1	0.0	18.1
S	5.9	10.9	3.7	1.2	0.6	0.1	0.0	22.4
SW	7.0	12.9	4.3	1.4	0.5	0.1	0.0	26.2
W	5.3	7.4	2.0	0.6	0.1	0.0	0.0	15.4
NW	2.9	2.1	0.6	0.1	0.0	0.0	0.0	5.7
TOTAL	31.1	47.1	15.2	4.7	1.6	0.3	0.0	100.0

Table 19 Average percentage frequency of occurrence of significant wave height-direction groups: Grand Isle Block 46: Offshore Louisiana: 110 foot mean low water depth: September (From Glenn, 1972).

Direction	Significant Wave Height Groups (ft.) 0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	10-15	15+	Total
N	1.5	2.2	1.3	0.8	0.4	0.1	0.0	6.3
NE	4.1	6.5	5.3	3.2	1.3	0.5	0.1	21.0
E	4.4	7.9	6.1	4.5	1.8	1.6	0.5	26.8
SE	2.4	5.4	6.1	4.7	2.0	2.1	0.8	23.5
S	1.1	2.5	2.7	2.1	1.0	0.9	0.3	10.6
SW	0.9	1.2	1.1	0.8	0.4	0.1	0.0	4.5
W	1.1	1.1	1.0	0.7	0.2	0.0	0.0	4.1
NW	1.2	1.4	0.5	0.1	0.0	0.0	0.0	3.2
TOTAL	16.7	28.2	24.1	16.9	7.1	5.3	1.7	100.0

Table 20 Average percentage frequency of occurrence of significant wave height-direction groups: Grand Isle Block 45: Offshore Louisiana: 110 foot mean low water depth: October (From Glenn, 1972).

Direction	Significant Wave Height Groups (ft.) 0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	10-15	15+	Total
N	2.3	4.0	3.0	1.9	0.7	0.1	0.0	12.0
NE	4.8	10.0	7.8	4.3	1.7	0.8	0.1	29.5
E	2.5	7.0	5.8	4.0	2.5	1.9	0.5	24.2
SE	1.2	3.2	4.0	3.4	1.9	2.1	0.4	16.2
S	1.0	2.1	2.3	1.4	0.6	0.3	0.1	7.8
SW	0.5	0.7	0.7	0.4	0.2	0.1	0.0	2.6
W	0.6	0.8	0.7	0.4	0.1	0.0	0.0	2.6
NW	1.2	2.5	0.9	0.4	0.1	0.0	0.0	5.1
TOTAL	14.1	30.3	25.2	16.2	7.8	5.3	1.1	100.0

Table 21 Average percentage frequency of occurrence of significant wave height-direction groups: Grand Isle Block 46: Offshore Louisiana: 110 foot mean low water depth: December (From Glenn, 1972).

Direction	Significant Wave Height Groups (ft.) 0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	10-15	15+	Total
N	1.5	4.5	4.1	3.6	2.1	0.7	0.1	16.6
NE	2.6	6.7	6.2	5.4	2.7	1.0	0.1	24.7
E	1.2	4.4	3.7	2.6	1.7	1.6	0.3	15.5
SE	0.7	2.6	3.6	3.1	2.2	2.6	0.4	15.2
S	0.6	2.1	2.7	2.3	1.6	1.1	0.3	10.7
SW	0.4	1.1	1.3	1.1	0.8	0.5	0.1	5.3
W	0.4	0.8	0.9	0.6	0.4	0.2	0.1	3.4
NW	1.7	2.1	2.3	1.7	0.7	0.1	0.0	8.6
TOTAL	9.1	24.3	24.8	20.4	12.2	7.8	1.4	100.0

D. Biology of the Coastal Zone

Introduction to the Marshes

Louisiana wetlands cover 30% of the area of the state for a total of 10 million acres (Viosca, 1928). Coastal marsh includes 4.2 million acres along the Gulf of Mexico from Texas to Mississippi. The marsh covers the modern and abandoned Mississippi River deltas along the southeastern part of the state and the stranded sea beaches or Chenier ridges along the southwestern coast. Throughout these areas, four marsh zones may be distinguished on the basis of salinity and vegetation. They are: saline, brackish, intermediate, and fresh marshes (Chabreck, 1972). Such zonation has been used by Chabreck (1972). Several workers, such as Palmisano (1971) and O'Neil (1949), prefer to combine part of the intermediate (nearly fresh) and fresh marsh in their research.

The four zones of plant associations are determined and controlled by synergistic or combined environmental parameters such as proximity to the Gulf of Mexico and its saline waters, tidal fluctuations, currents and storms. The extent of saline intrusion into the marsh depends to a large degree on the rate of percolation of saltwater at high tide (Jackson, 1952), and the location of points of influx of freshwater from the mainland. Numerous other parameters fluctuate within the marsh and stimulate or retard the growth of particular species. Such factors include: pH, which may become more acidic as vegetation decomposes; temperature, which may vary with water

depth and circulation; nutrient supply, which may depend on freshwater flooding or tidal rinsing; condition of the substrate. The latter include mud flat, clay pan, silt, organic soils, thick matted peat deposit, or combinations of the above.

In addition to these physical and chemical factors, the plant and animal communities - living components of their own environment - are themselves biological parameters integral to the continuation of the marsh. The establishment of one species of plant, for example, makes possible the success of other organisms which benefit from the plant's protective stalks, roots, or food produced through photosynthesis. The fur-bearing muskrat thrives in the Louisiana brackish marsh after the establishment of three-cornered grasses, the tubers of which it eats (O'Neil, 1949). When the supply of this plant species diminishes because of nutrient depletion or over-colonization by the muskrat, the animal must move on, or die, until the plant can re-establish itself in the area.

Although the marsh is considered one of the most highly productive biomes (major type of environment) in the world (Odum, 1971, Whittaker, 1970), it does not always support an extensively developed food web of its own. Much of the energy produced by the marsh in the form of grasses -- especially in the salt marsh -- is flushed into the Gulf where it ultimately supplies other food webs. What remains in the marsh is either stored as peat or consumed by detritus

(bacteria fungi) feeders. For example, in the Georgia saltmarsh, periodic tidal flushing results in the loss into the estuary of 45% of the new production in the marsh (Teal, 1962). The remaining 55% of the plant material is used by secondary consumer respiration (47% of bacteria) (Teal, 1962). The primary species in the Georgia marsh is Spartina alterniflora, the same plant, commonly called oystergrass, which also dominates in the Louisiana delta saltmarsh.

The comparatively small number of plant species of the saltmarsh limits the number of available niches in which organisms may live. Chabreck (1972) recorded only 17 plant species present in the coastal saltmarsh. However, with the inland marsh succession, habitat complexity increases significantly. The same author noted 93 plant species present in the fresh marsh. Yet in the saltmarsh, there is a lack of variety of possible niches such as could be found in a forest of the same latitude (Teal, 1962). Since much marsh productivity goes to nourishing other ecosystems, the number of resident animals which depend on this ecosystem for their entire livelihood is also limited. Resident marsh species include the furbearing muskrat, nutria, mink, raccoon and otter which, on a statewide basis, accounted for 96% of the 1971-72 Louisiana take of fur animals. (From figures of the Louisiana Fish and Wildlife Commission, 1971). The marsh also provides habitat for the mammalian deer, rabbit and squirrel, numerous reptiles and amphibians, fish and shellfish which may permanently reside in the area or migrate

there for purposes of breeding, feeding, or rearing of young.

Three regions of different geological origin characterize the coastal marsh. The first Chenier Plain or Prairie Marshes (Penfound and Hathaway, 1938, O'Neil, 1949), consist of 760,000 acres along the western coast of Louisiana. They are the oldest marshes with a firmer foundation and elevation which may extend to 5 feet above sea level along the Grand Chenier Ridge. "The general picture of the (prairie) marsh is one of shallow peat soils ranging in depth from five to six feet but interlaced to some extent by deeper veins of peat that are the remains of filled-in streams" (O'Neil, 1949). The region is characterized by a very narrow zone of salt marsh along the coast with the sea rim or ridge extending behind it along most of the shore. Numerous inland Chenier ridges - stranded sea beaches - parallel the Gulf and provide series of intermediate and fresh marshes behind them. Accordingly, the Chenier is poorly drained and includes wide zones of intermediate and fresh vegetation. Portions of the fresh and prairie Chenier is farmed for rice. The ridges of the Chenier have been grazed by cattle, settled and paved by man, and burned for clearing and the enhancement of three-cornered grass for muskrats.

The inactive delta, produced by the silt deposits from abandoned Mississippi River deltas consists of 2,940,000 acres which stretches from the western end of Vermilion Bay to Lake Borgne in the east. Today the region is a combination of all four marsh zones which sometimes

extends inland for distances approaching 60 miles. The abandoned river channels have become the bayous which traverse the fresh and brackish marsh before reaching the Gulf. The inactive delta is the largest region of Louisiana coastal salt marsh (Chabreck, 1972), and is subsequently more exposed to direct environmental influences of the Gulf of Mexico than is the Chenier. Tidal influence and Gulf waters reach further into the abandoned delta than into either the Chenier or the modern delta.

The active delta marshes consist of approximately 300,000 acres and are of recent geological origin (O'Neil, 1949). Because the delta cradles the flow of the Mississippi River to its termination in the Gulf, the central delta marsh is inundated with fresh water. Fresh to intermediate vegetative combinations cover 85% of the area (Chabreck, 1972). This 126,000 acre central portion of the delta supports a rich community of organisms to be illustrated in a subsequent discussion of fresh marsh. Salt marsh again permeates the delta north of the town of Triumph in central Plaquemines Parish and thereafter covers the entire delta peninsula.

Substrates of the delta include mudflats, levee surface and embarkment, peat deposits and sand. Faunal assemblages naturally vary according to these types of environment. Although man has influenced the delta by increasing the Mississippi River's silt load and by construction of artificial levees, he has had less adverse effect on this area than in the Chenier or abandoned deltas where cattle

grazing and agriculture have altered expanses of natural successional growth.

Estimates of vegetative cover by Chabreck (1972) are based on a series of linear transects taken aerially at quarter mile intervals along the Louisiana coast from Texas to Mississippi with on land verification of species composition recorded at every eighth experimental station (Personal communication). Results of this survey are presented in Table22 on the following pages.

Table 22. Plant Species Composition of Vegetative Types in the Louisiana Coastal Marshes, According to Four Zones. (From Chabreck, 1972)

Species	VEGETATIVE TYPE			
	Saline	Brackish	Intermediate	Fresh
	Percent			
Acnida alabamensis	---	.10	.30	.02
Aeschynomene virginica	---	---	---	.07
Alternanthera philoxeroides	---	---	2.47	5.34
Aster sp.	---	.08	.44	.13
Avicennia nitida	.60	---	---	---
Azolla caroliniana	---	---	---	.13
Baccharis halimifolia	---	.10	.56	.02
Bacopa caroliniana	---	---	.28	.34
Bacopa monnieri	---	.92	4.75	1.44
Bacopa rotundifolia	---	.11	.32	---
Batis maritima	4.41	---	---	---
Bidens laevis	---	---	---	.08
Borrichia frutescens	.67	.11	---	---
Brasenia schreberi	---	---	---	.67
Cabomba caroliniana	---	---	---	.71
Carex sp.	---	---	---	.02
Centella erecta	---	---	.16	.12
Cephalanthus occidentalis	---	---	---	.21
Cerathophyllum demersum	---	---	---	1.50
Cladium jamaicense	---	---	---	.84
Colocasia antiquarum	---	---	---	.39
Cuscuta indecora	---	.02	---	---
Cynodon dactylon	---	---	---	.10
Cyperus compressus	---	---	---	.02
Cyperus odoratus	---	.84	2.18	1.56
Daubentonia texana	---	---	.04	.17
Decondon verticillatus	---	---	---	.51
Dichromena colorata	---	---	---	.03
Distichlis spicata	14.27	13.32	.36	.13
Dryopteris thelypteris var. haleana	---	---	---	.44
Echinochloa walteri	---	.36	2.72	.77
Eichornia crassipes	---	---	---	1.43
Eleocharis parvula	---	2.46	.49	.54
Eleocharis sp.	---	.82	3.28	10.74
Eupatorium capillifolium	---	---	---	.05

Table 22 (cont')

Species	VEGETATIVE TYPE Saline	Brackish	Intermediate	Fresh
	--------	--------Percent	--------	--------
Eupatorium sp.	---	---	.08	.03
Fimbristylis castanea	.04	.11	.12	---
Gerardia maritima	.01	.08	---	---
Heliotropium curassavicum	---	.02	---	---
Hibiscus lasiocarpus	---	---	.10	.05
Hydrocotyle bonariensis	---	---	---	.02
Hydrocotyle ranunculoides	---	---	---	.11
Hydrocotyle umbellata	---	---	---	1.93
Hymenocallis occidentalis	---	---	.04	.14
Hypericum virginicum	---	---	---	.07
Ipomoea stolonifera	---	---	---	.03
Imponoea sagittata	---	.13	.84	.19
Iva frutescens	.03	.10	---	---
Juncus effusus	---	---	---	.11
Juncus roemerianus	10.10	3.93	.72	.60
Jussiaea diffusa	---	---	---	.24
Jussiaea sp.	---	---	---	.84
Kosteletzkya virginica	---	.02	.18	.07
Kemna minor	---	.02	.16	2.31
Leptochloa fascicularis	---	.32	2.17	.49
Leptochloa filiformis	---	---	.04	---
Limnobium spongia	---	---	---	.16
Lippia nodiflora	---	---	---	.06
Lycium carolinianum	.07	---	---	---
Lythrum lineare	.01	.16	.18	.07
Myrica cerifera	---	---	---	.16
Myriophyllum spicatum	---	.15	.44	1.56
Myriophyllum heterophyllum	---	---	---	.19
Najas quadalupensis	---	---	1.03	1.07
Nelumbo lutea	---	---	---	.54
Nyphaea odorate/tuberosa	---	---	---	1.15
Nymphoides aquaticum	---	---	---	.11
Osmunda regalis	---	---	.16	.43
Ottelia alismoides	---	---	---	.03
Panicum hemitomon	---	---	.76	25.62
Panicum repens	---	---	.92	.24
Panicum virgatum	---	.14	2.51	.45
Panicum sp.	---	---	---	.10

Table 22 (cont')

Species	VEGETATIVE TYPE Saline	Brackish	Intermediate	Fresh
	---------------Percent-------------------			
Paspalum dissectum	---	---	.40	.42
Paspalum vaginatum	---	1.38	4.46	.35
Philoxerus vermicularis	---	---	.08	.01
Phragmites communis	---	.31	6.63	2.54
Pluchea foetida	---	---	---	.02
Pluchea camphorata	---	.87	2.26	.36
Polygonum sp.	---	---	---	.56
Pontederia cordata	---	---	---	.07
Potamogeton nodosus	---	---	.28	.03
Potamogeton pusillus	---	---	.24	.62
Ruppia maritima	---	3.83	.64	---
Sacciolepis striata	---	---	---	.06
Sagittaria falcata	---	---	6.47	15.15
Sagittaria latifolia	---	---	---	.21
Sagittaria platyphylla	---	---	---	.23
Sagittaria sp.	---	---	.08	---
Salicornia bigelovii	.13	---	---	---
Salicornia virginica	.63	---	---	---
Salix nigra	---	---	---	.06
Saururus cernuus	---	---	---	.16
Scirpus americanus	---	---	1.27	.13
Scirpus californicus	---	---	1.83	.42
Scirpus olneyi	---	4.97	3.26	.45
Scirpus robustus	.66	1.78	.68	---
Scirpus validus	---	.08	---	---
Sesbania exaltata	---	.06	.20	---
Seauvium portulacastrum	---	.04	---	---
Setaria glauca	---	.06	---	---
Setaria magna	---	---	---	.03
Solidago sp.	---	---	.04	.08
Spartina alterniflora	62.14	4.77	.86	---
Spartina cynosuroides	---	.89	1.19	.02
Spartina patens	5.99	55.22	34.01	3.74
Spartina spartineae	.01	.04	1.48	---
Spirodela polyhiza	---	---	---	.20
Suaeda linearis	.23	---	---	---
Taraxacum officinale	---	---	.02	---
Taxodium distichum	---	---	---	.02

Table 22 (cont')

Species	VEGETATIVE TYPE			
	Saline	Brackish	Intermediate	Fresh
	---------------Percent---------------------			
Typha spp.	---	---	.98	1.57
Utricularia cornuta	---	---	---	1.68
Utricularia subulata	---	---	---	.21
Vallisneria americana	---	.08	---	---
Vigna repens	---	1.20	3.84	1.43
Woodwardia virginica	---	---	---	.28
Zizaniopsis miliacea	---	---	---	1.20

The four marsh zones as delineated in the study of Chabreck (1972) and as illustrated on a map prepared by Chabreck, Joanen and Palmisano (1968) under the auspices of the Louisiana Wildlife and Fisheries Commission are illustrated on the following pages. Figure 23 a to g.

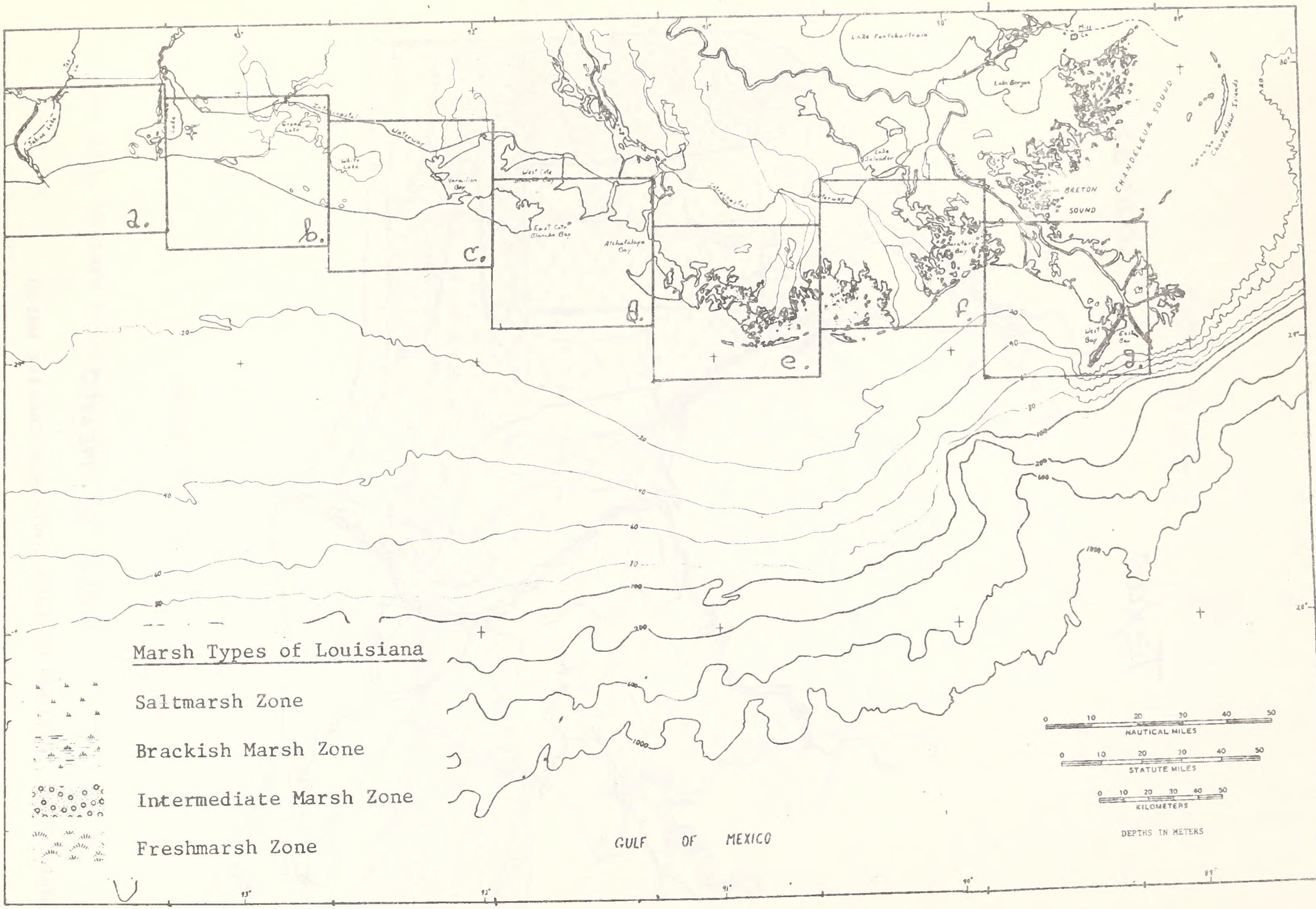

Figure 23. a-g. Marsh types of Louisiana. Legend for following pages is designated above.

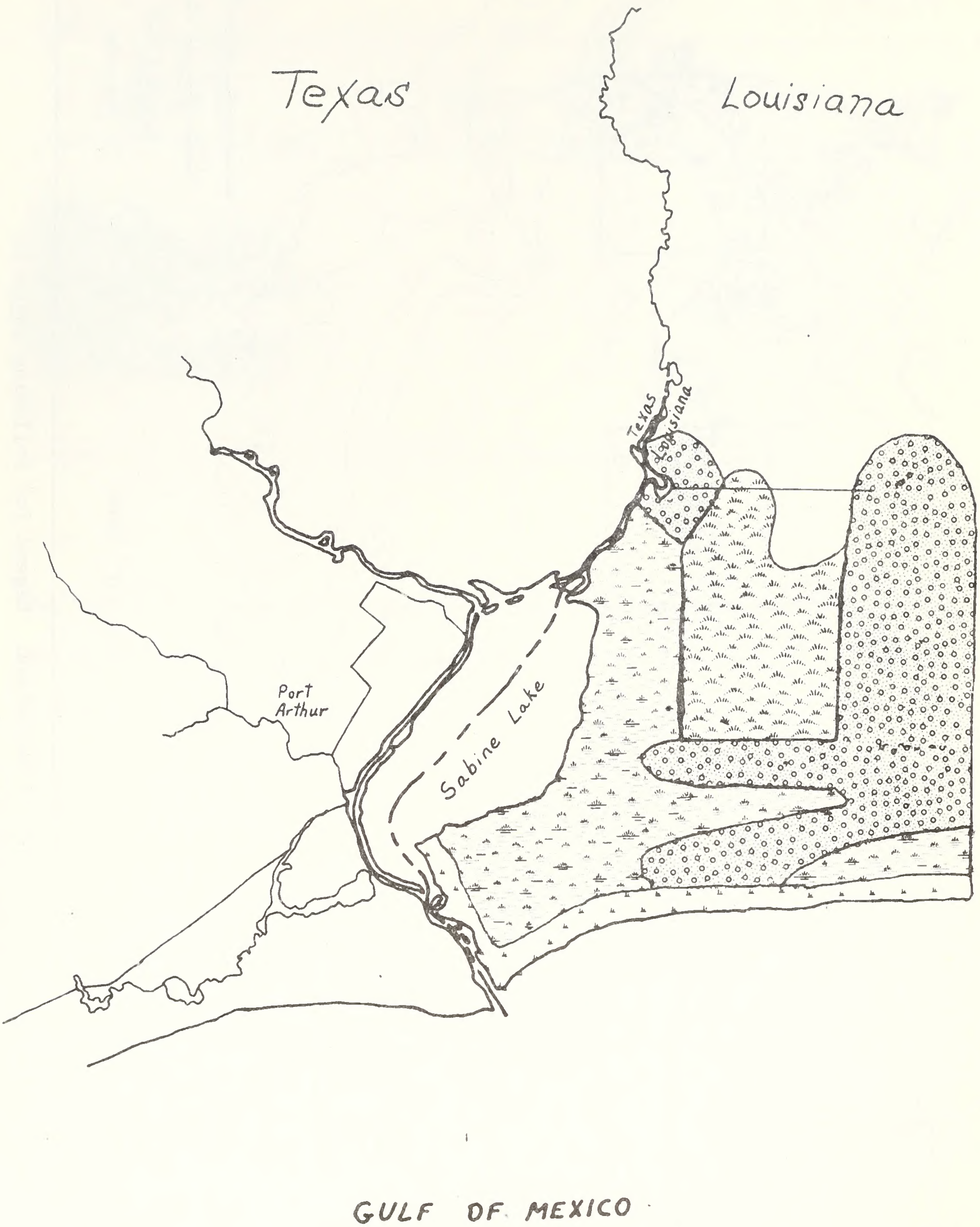

Figure 23-a. Extreme western Louisiana chenier marsh.

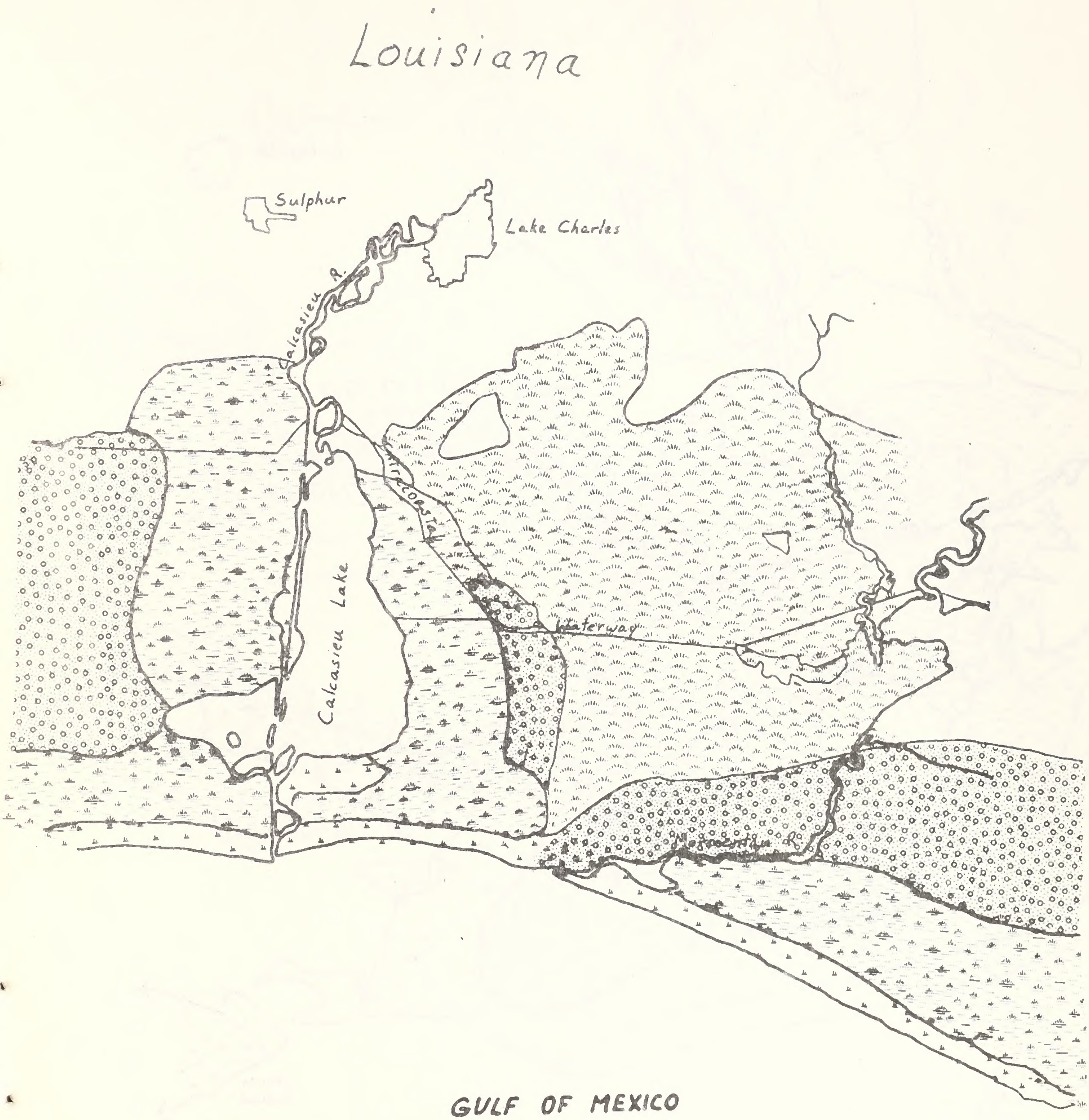

Figure 23-b. Western Louisiana chenier marsh.

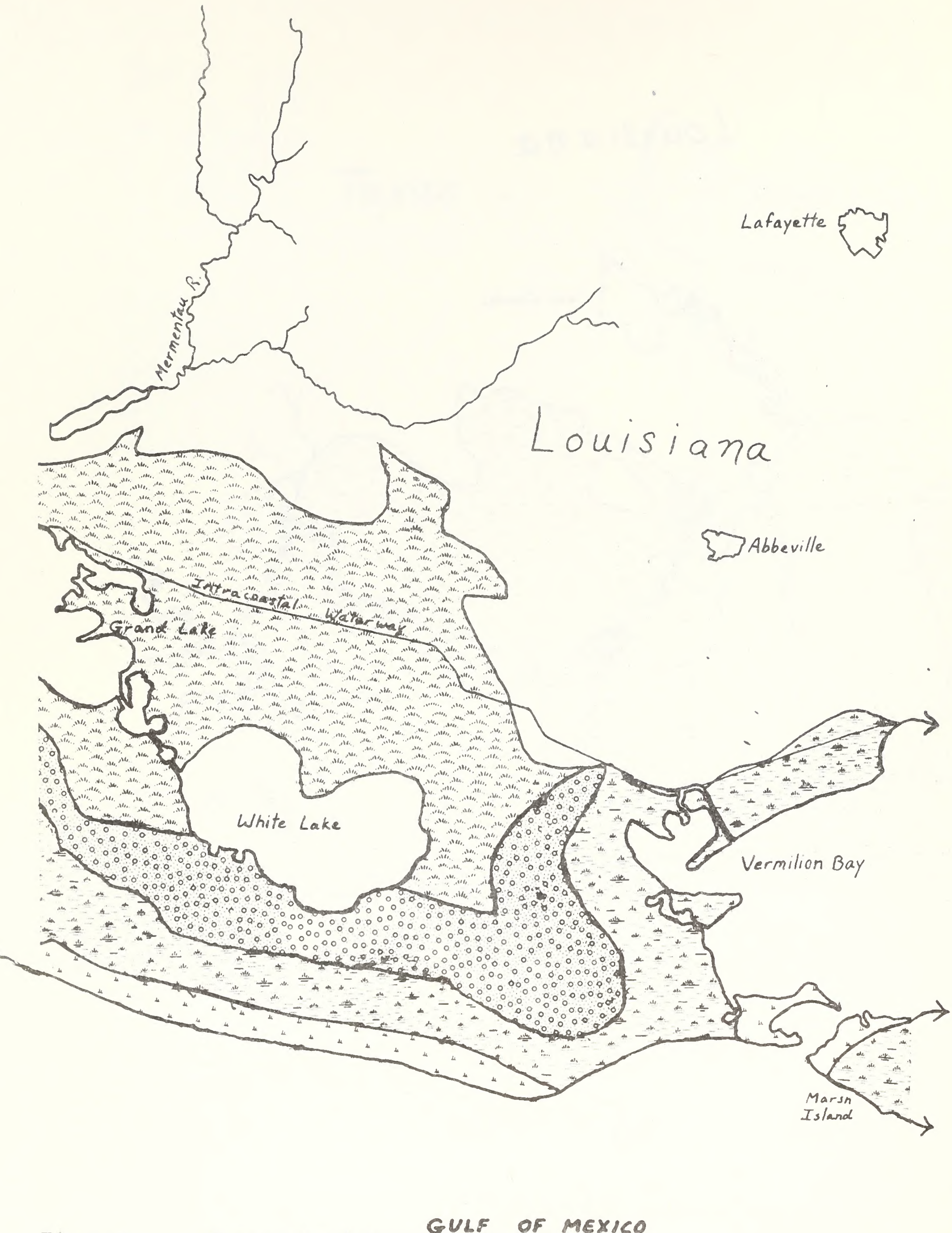

Figure 23 -c. West-central Louisiana chenier marsh.

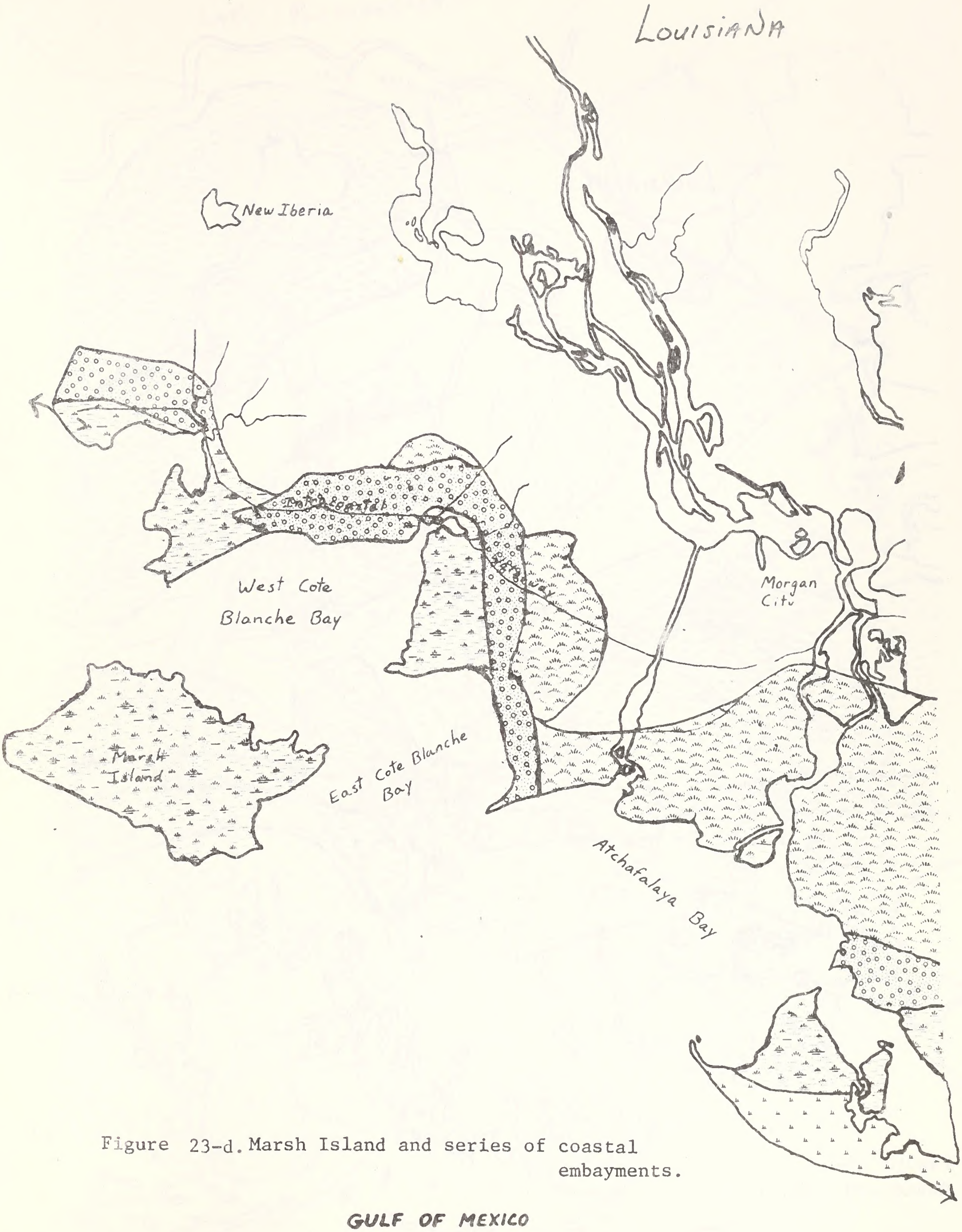

Figure 23-d. Marsh Island and series of coastal embayments.

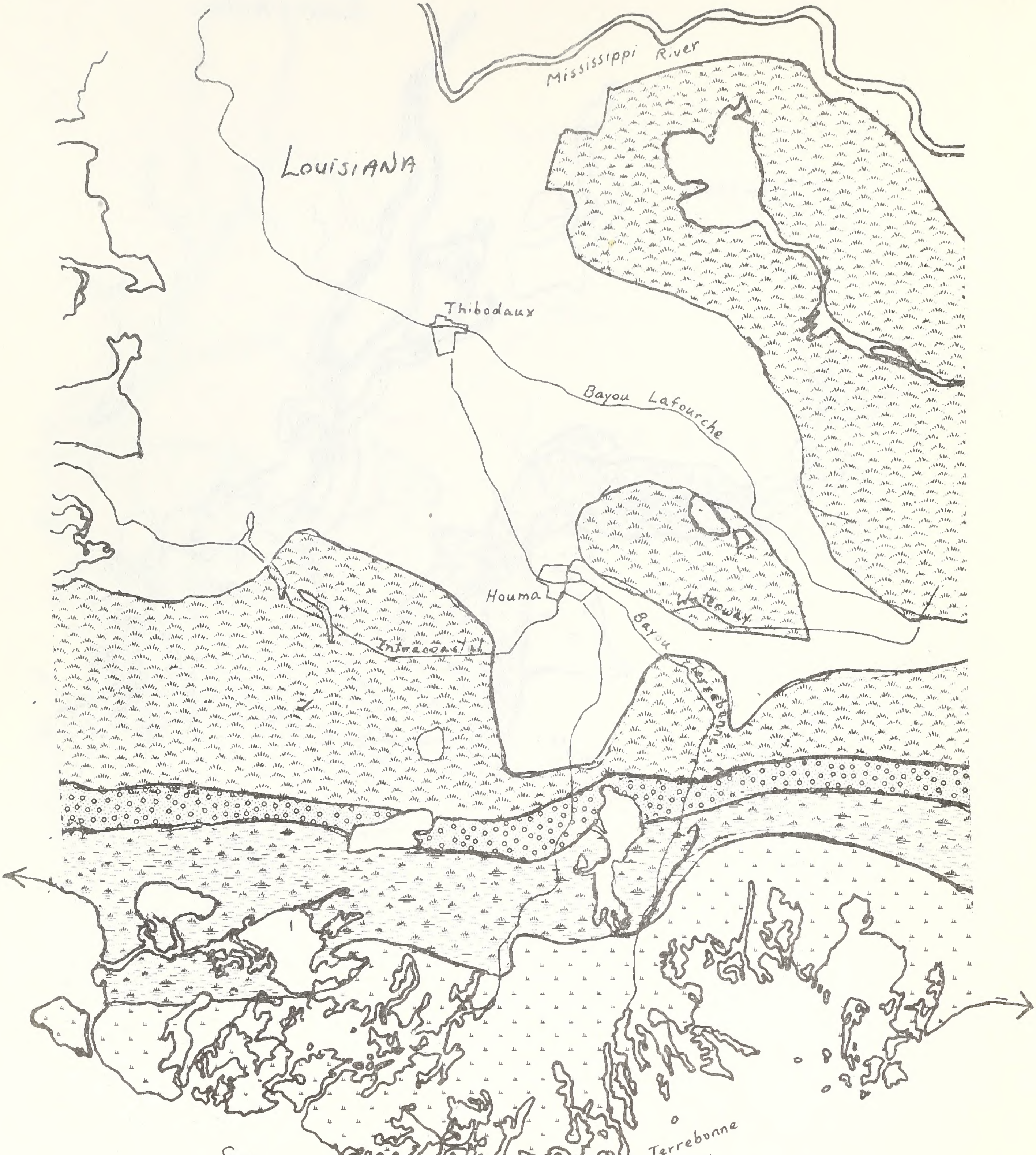

Figure 23-e.
Abandoned Teche Delta

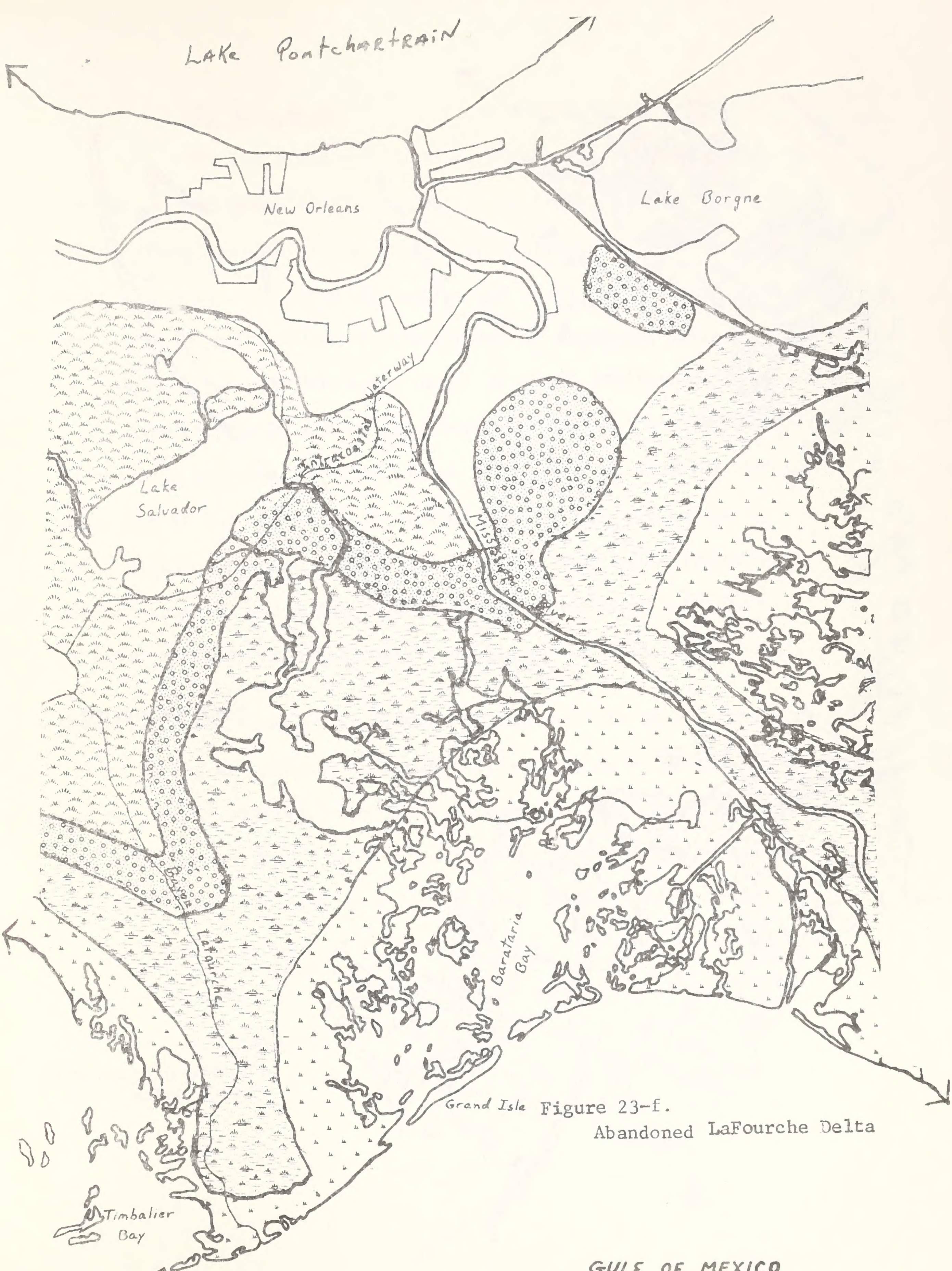

Figure 23-f.
Abandoned LaFourche Delta

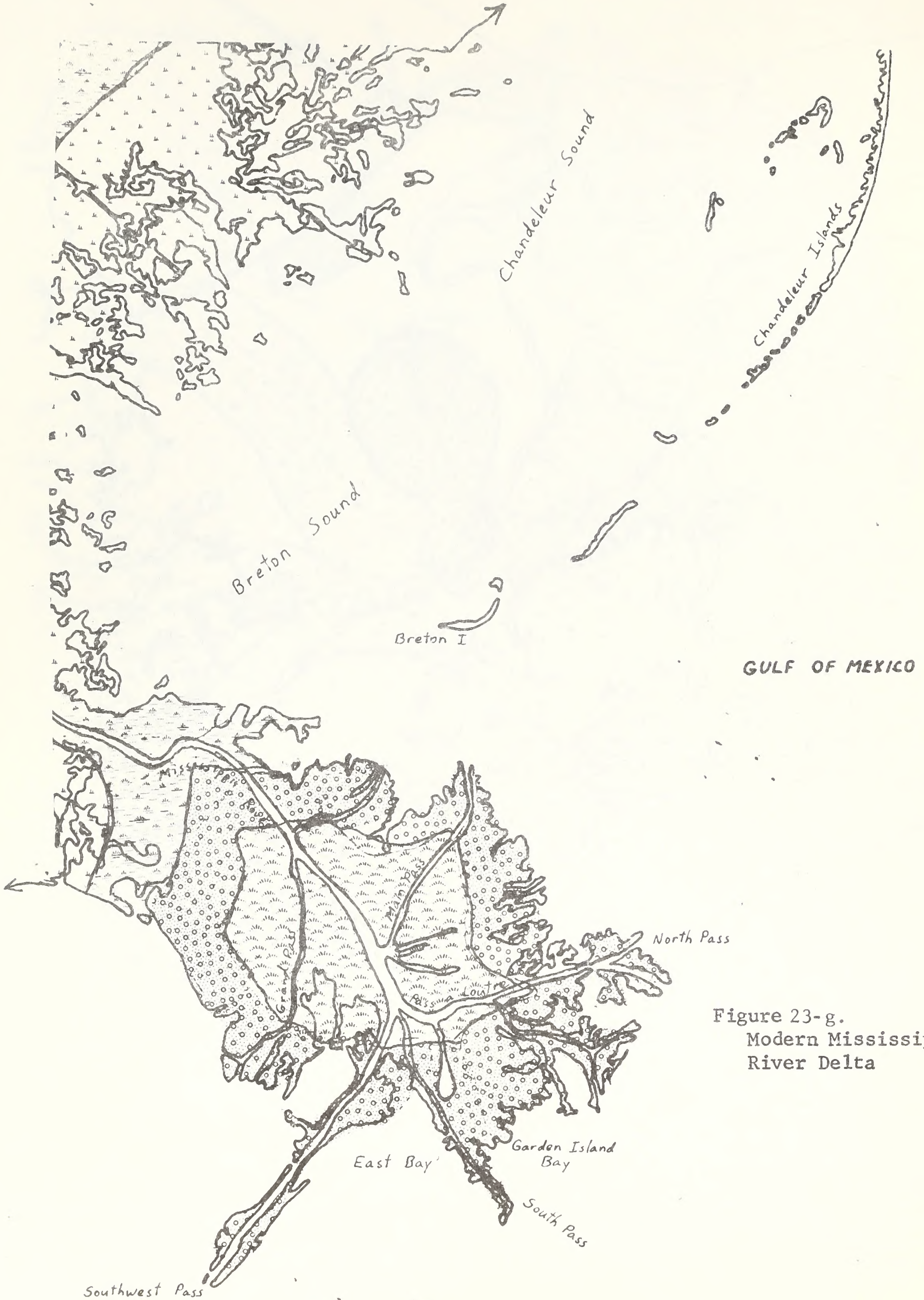

Figure 23-g.
Modern Mississippi
River Delta

1. <u>The Salt Marsh</u>

The Louisiana salt marshes extend continuously along the Gulf Coast from Texas to Mississippi in an irregular band of varying width. These marshes extend inland for distances of less than a mile along the sea rim in parts of Cameron and Vermilion Parishes and from 10 to 15 miles inland in the regions of abandoned deltas. The salt marsh covers 931,400 acres or 22.1% of all Louisiana coastal marshland (Chabreck, 1972) and may be considered as the first major biological buffer zone between the biota of the freshwater mainland and the marine organisms of the Gulf. "Salt marshes provide much protection to low lying uplands adjacent to them not only from salt water intrusion, coastal erosion, and quantities of drifting debris, but in the case of broad marshes, from destructive salt spray as well (Humm, 1973).

The salt marsh resembles a pioneer environment. In such an environment, a few species are adapted to ecological conditions which are too severe for most other species. The fluctuating tide levels which alternately expose the marsh plants to temperatures and moisture gradients of air and salt water, the lack of a firm substrate and the highly saline soils inhibit the development of further successional stages along the coast of the saltmarsh. As the salinity levels decrease with progression into the marsh, such ecological succession may be noted. Only 17 of 118 species of vascular plants of the Louisiana marshes are found in the

salt marsh zone (McGinnis, *et al.*, 1972). Of these 17, twelve account for less than 1.0% of the vegetation (Chabreck, 1972). Species diversity of plants is lower in the salt marsh than in any of the three inland zones.

The dominant plant, oystergrass, *Spartina alterniflora*, accounts for 62% of all salt marsh vegetation. This plant is most densely distributed along the seaward side of the marsh. Of all marsh species, oystergrass is best able to endure the longest and deepest inundation by saltwater (Humm, 1973). Different species of *Spartina* grass are successful in covering the shore of an area because of the rigid erect stems and creeping rootstock which is effective in binding soft mud (Green, 1971). *Spartina* forms dense tussocks which reach a height of over a meter. These tussocks help to build the marsh as two different sets of roots grow both horizontally and vertically and penetrate the mud. The rate of accumulation of new sediment is greater in an area of *Spartina* than in any other part of the estuary, because the stems plow the tidal movement of water passing through them.

Blackrush, *Juncus roemerianus*, is distributed throughout the saltmarsh on slightly higher ground than oystergrass. This marsh plant grows to heights of six feet and slows down horizontal water flow through the marsh. During such tidal

rinsing of the marsh, the rush stems accumulate organic material from the remains of other plants and continue forming peat deposits. Although it accounts for only 10.10% of the species composition of the saltmarsh grass (Chabreck, 1972). the black rush is widely distributed in the marshes.

Saltgrass, Distichilis spicata, which comprises 14.27% of the total marsh vegetation (Chabreck, 1972) is limited to a more inland location in the saltmarsh. This plant grows on slightly higher elevation than the peat deposits to which it contributes, and is inundated only in storm tides. Saltgrass requires a more highly organic soil than that which supports expanses of oystergrass (Chabreck, 1971).

Batesgrass, Batis maritima, and wiregrass, Spartina patens, make up 4.4 and 6.0% of the Louisiana saltmarsh, respectively. Twelve remaining species account for less than 1% of total vegetation in the saltmarsh.

Periodic rise and fall of the tide regulates the distribution of the saltmarsh. Oystergrass, which does not grow above the level of the highest periodic tide (Kurz, 1953), is restricted to the outer regions of the marsh in which such tides occur. The less salt tolerant saltgrass grows in positions shielded from the tide. Figure 24 illustrates a marsh and delta community.

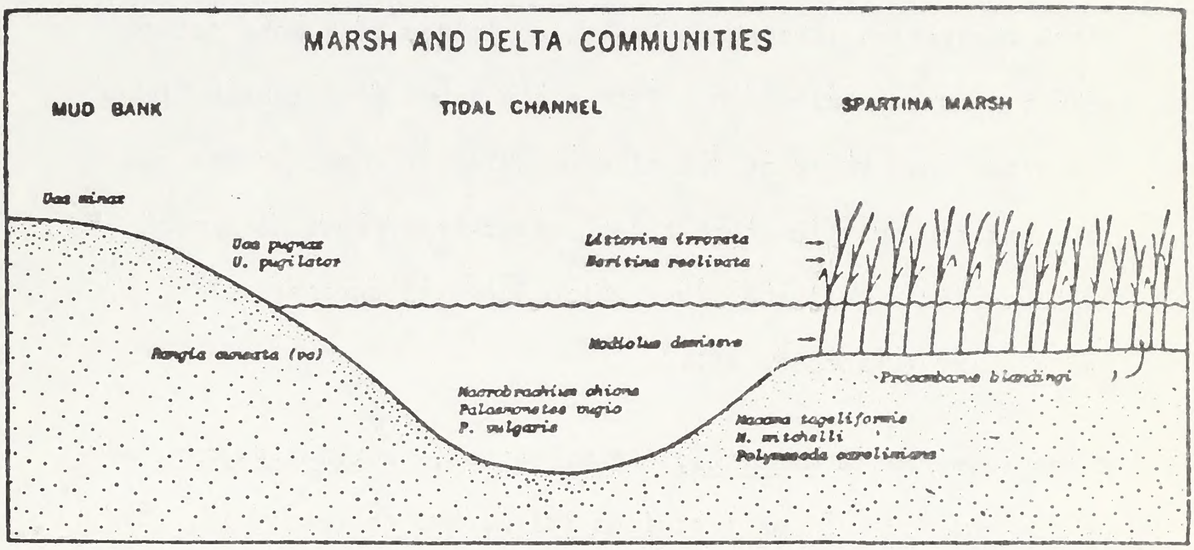

Figure 24. Carolinian affinities. These communities occur in the study area between the Mississippi barrier islands and Cedar Key, Florida. (Collard and D'Asaro, 1973). These communities also occur in the Spartina alterniflora and Juncus roemerianus marshes of Louisiana.

Primary productivity in the marsh is comparable to that of other major biomes of the world. According to Whittaker (1971), primary productivity for the swamp and marsh ecosystems of the world is similar to tropical forest or estuarine biomes. Humm (1973) maintains that such comparisons between productivity of marsh plants and land plants are invalid because of their divergent uses. However, the divergent uses of plants has nothing to do with how much carbon is fixed per unit area per unit time (the productivity of the plant). A productivity comparison between such ecosystems has been made by Odum (1971).

Annual net production by Spartina alterniflora is higher in Louisiana than in other major marsh ecosystems of the North American Atlantic/Gulf coast. This higher rate of production is indicated in Table 23, taken from Day, et al, (1973).

Table 23 ANNUAL NET PRODUCTION OF SPARTINA ALTERNIFLORA MARSHES g dry wt/m^2/yr (Day, et al, 1973)

	Inland	Streaside	Combined	Reference
Louisiana	1,484	2,960	-	Kirby, 1971
New York	508.3	827.2	-	Udel, et al, 1969
Delaware	--	--	445	Morgan, 1961
North Carolina			650	Williams, Murdock, 1969
North Carolina	329.0	1,296.0	-	Stroud, Cooper, 1968
North Carolina	610	1,300	-	Marshall, 1970
Georgia	643.2	1,098.0		Smalley, 1959

Net production of oystergrass at streamside and inland areas in the saline marsh at Barataria Bay has been measured (Day et al, 1973). Streamside productivity was 30% higher than for inland marsh area, and was cited as the highest rate of productivity recorded for any saltmarsh. Net production at streamside was 2800 g dry wt./m^2/yr. The significance of so high a rate of energy production is not fully known. "While basic productivity of the saltmarshes is high, since they act as coastal nutrient traps and are little affected by droughts, the significance of so high a rate of production is not known. Speculation on its value has been considerable and is illustrated by the statement that 95% of the commercial fisheries catch in Virginia is 'nurtured by the marshes' (Hitchcock, 1972)

Most of the energy produced by the saltmarsh is lost to other ecosystems. The Center for Wetland Resources estimates that 42% of the organic matter from marsh grass gets washed out by tidal actions into Barataria Bay, Louisiana (Stone, 1972). In this way the saltmarshes provide much of the necessary energy for other parts of the Gulf-estuarine complex through the washing-out action of the tides.

Because they first developed during the Pleistocene, the world's saltmarshes have achieved the stability characteristic of

ancient environments (Teal, 1962). Stability may be achieved when the ecosystem has many species with restricted diets so that competition for food between the species is minimal. Stability may also result when an ecosystem has fewer species with broad diets (MacArthur, 1955). As long as there is sufficient food for these latter organisms, they are not particular about what they eat. This second case is typical of the salt marsh. "Among the detrital-algae feeders, there are only a few important (animal) species which have an unrestricted diet. There are only a few species among the carnivores which prey on the detrital feeders and they too have an unrestricted diet (Teal, 1962)."

Representatives of all four categories of the food web (producers, herbivores, carnivores, and decomposers) inhabit the Louisiana marshes for at least part of their life cycle.

The salt marsh features a food web of a few species of primary producers (oystergrass, black rush, saltgrass) which has one of the highest known rates of production. Yet few carnivores inhabit the saltmarsh. The alligator, while occasionally present in the saltmarsh, is a resident of fresher waters where a more diverse food web abounds. Of the approximately 50% of the oystergrass which is not washed out from the saltmarsh, approximately half is consumed by decomposing organisms and detrital feeders.

Some forms peat deposits and a minute amount is consumed by herbivorous insects which may become the food of birds. Thus, little of the energy produced by the saltmarsh is available to an organism in the immediate area. An exception would be invasions by the muskrat which prefers tubers of the brackish water three-cornered grasses, Scirpus robustus and S. olneyi, but also extends into the salt and freshwater marshes (Louisiana Wildlife Inventory, 1959).

With increased distances from the coastlines of the delta regions and behind the more elevated sea rims, a noticeable change in plant associations signals the lowering of salinity gradients. As a result of tidal interference by marsh plants, more elevated marsh plains caused by silting or peat, and introduction of freshwater from the mainland, the subsequent variation in plant communities begins to define a new ecosystem. In this way the saltmarsh blends into the brackish and fresher marshes and subsequently into the swamps, bayous or forest of Louisiana.

2. The Brackish Marsh

Brackish marshes occupy the entire length of the Louisiana coast except a 25 mile stretch of fresher marsh along Atchafalaya Bay. They are usually situated between the seaward salt marsh and landward intermediate and fresher marshes. According to Chabreck (1972) they are the second largest marsh zone comprising 30.5% (or 1,295,000 acres) of the total Louisiana coastal marshes. The major portion of the brackish marsh spreads into the delta region for distances of up to 16.2 miles. Behind the sea rims of the Chenier plain in the western delta, there is less brackish and more intermediate to fresh marsh. The wiregrass-saltgrass associations of the brackish zone extend for a maximum 5.2 miles inland within the Chenier (Chabreck, 1970). Brackish marshes surround Sabine and Calcasieu Lakes, Vermilion, Cote Blanch, and Four League bays. The more centrally located, slightly saline, lakes of the Chenier (such as Grand and White lakes) are surrounded by fresh water marshlands.

The delta brackish marsh stretches continuously from Four League Bay on the western delta plain to Lake Borgne at the southeastern end of Louisiana. Bayou La Fourche, Bayou Terre Aux Boeuf and the Mississippi River provide for armlike extensions of the marsh into the more saline regions of the delta. The brackish zone includes Lakes De Cade, Mechant, Lery, Little Lake, Catherine and to some extent, Pontchartrain.

Salinities in the brackish marsh vary annually between an average low of 3.4 ppt to an average high of 16.7 ppt. Highest salinities occur in June, or in the drought periods (Palmisano, 1971).

Plant species diversity increases as the marsh approaches the terrestrial forest environment. Forty species of plants (Chabreck, 1970) have been recorded in the brackish marsh. The dominant species wiregrass, Spartina patens, comprises 55% of the total vegetation. Saltgrass, Distichlis spicata, makes up 13.13% of the remaining 38 species. Only 5 other species have been recorded with coverage greater than 2-5%. These include three-cornered grass, Scirpus robustus, oystergrass, Spartina alterniflora, blackrush, Juncus roemerianus, widgeon grass, Ruppia maritma, and dwarf spikerush, Eleocharis parvula, (Chabreck 1970).

Wiregrass grows in the shallower salt marshes, especially where there is an influx of sandy soil from higher ground (Humm, 1973). It acts as a later successional stage to the oystergrass and blackrush of the salt marsh and, as such, would be expected to provide a continuation of this ecological succession. However, Humm (1973) states that "...no one has obtained supporting experimental evidence or studied the marsh area long enough to observe much successional progress" although such speculation exists (Whittaker, 1970; Chapman, 1960).

The brackish marshes have been considered the most productive of all marsh zones. The detritus-algae food web combination of this

marsh is supplemented by additional herbivores and carnivores which consume the energy, occasionally extending the food web to man, as in the case of three-cornered grass to muskrat to man.

Consumers in the brackish marsh represent all categories of the food web and include bacteria and fungi attached to detrital particles, snails, bluecrab, polychaetes, insects, some waterfowl, reptiles and mammals. Brackish marsh is the primary home for the muskrat. The marsh fauna will be discussed in greater detail in a subsequent section.

3. The Intermediate Marsh

Extending further inland than the brackish marshes and distributed predominantly in the southwestern regions of the Chenier, the marshes of intermediate assemblages of vegetation comprise about 16.3% of Louisiana's marshlands (Stone, 1972). These marshes cover an area of 686,300 acres and are characterized by fairly diverse plant associations and salinities ranging from 5 to 10 ppt (U.S.Army Corps of Engineers, 1973). The marsh forms a narrow ribbon of several miles width between the brackish and freshwater marshes in the delta from the Mississippi River to Four League Bay. Whithin the Chenier plain this marsh becomes both more extensive and irregular in its distribution. In Cameron Parish, this marsh zone reaches to the Gulf beaches to the South, near Johnson's Bayou and extends inland along irregular basins for distances of up to 25 miles exclusive of Sabine National Wildlife Refuge. The greatest percentage of all intermediate marsh is located in the Chenier including much of the northern regions of the Rockefeller Wildlife Refuge.

A more diverse vegetation occurs in the intermediate marsh than the brackish of saline. Based on the data given by Chabreck (1970), fifty-four species of plants or 35% more than in the brackish zone live in the intermediate marshes. The dominant wiregrass makes up a third of the vegetation. Roseau, *Phragmites communis*, and bulltongue, *Sagittaria falcata*, form 6.63% and 6.47% of the vegetation respectively. Species present in abundance greater than 1 percent of the vegetation include

alligator weed, _Alternathera philoxeroides_, water hipsop, _Bacopa monnieri_, Walter's millet, _Echinochola crusgalli_, spike rush, _Eleochoris alba_, feather grass, _Panicum virgatum_, camphorweed, _Pluchea camphorata_, three cornered grass, _Scirpus robustus_, deer pea, _Vigna luteola_, _Cyperus odoratus_ and _Paspalum vaginatum_. Five species were listed as minor and the remaining 35 species comprised less than 1 percent of the vegetative composition. The intermediate marsh buffers the vegetation of the brackish marsh and the true freshwater marsh plants.

The less salt tolerant vegetation of the region such as saw grass, _Cladium jamaicense_, readily delineates the intermediate marsh from purely fresh sections which are populated by broadleaf cattail, _Typha_, and giant bullrush (Penfound and Hathaway, 1938). Intermediate marsh is heavily colonized by mammalian fur bearers. Natural plant distribution has been significantly altered in much of the marsh because of the fur mammal management practices of man. Much of the marsh has been burned, or burned and sodded to provide stands of three cornered grass and other muskrat foods.

4. The Fresh Marsh

Fresh marsh comprises the largest zone of the Louisiana coastal marsh covering 30.8% (or 1,299,400 acres) of the total marsh area (Chabreck, 1970). By considering the zones of fresh and intermediate marsh as one environmental unit, Palmisano (1971) estimates the fresh marsh to cover 1,870,000 acres. Within the fresh marsh zone, 250,000 acres in the northern parishes of the coastal zone are floating or "tremblant" marsh (O'Neil, 1949).

Salinities in the fresh marsh range from 1-5 ppt (U.S. Army Corps of Engineers, 1973) and tidal fluctuation is absent except during the drought season and extreme high tides (O'Neil, 1949). Water and nutrients are supplied to the marsh by flooding from the plain, streams, bayou and the Mississippi River. Construction of artificial levees, however, has resulted in nutrient depletion in parts of the marsh no longer periodically flooded by the Mississippi.

The fresh coastal marsh is situated between the intermediate-brackish marshes to the south and the Mississippi Alluvial Plain or prairie formation to the north (Palmisano, 1971). The three major physiographical regions of the coastal marsh each include within them a separate expanse of fresh marsh. These sections of fresh marsh, each with a unique set of soil and topographic conditions, vegetate the inland extent of Chenier marsh, the innermost marshes of the abandoned deltas and the central area of the modern Mississippi delta.

In the Chenier of southwestern Louisiana, fresh marsh is dominated by a plant association of bulltongue, Sagittaria falcata, and alligatorweed, Alternanthera philoxeroides (Palmisano, 1971). The fresh-intermediate marshes are separated from the brackish-saline marshes by the Grand Chenier Ridge, the highest stranded beach. As a transitional area, the ridge supports a mixture of vegetative species, none of which gains complete control. Approaching the fresh marsh beyond the northern slope of Grand Chenier, the fresh species yellow cutgrass, Zizaniopsis miliacea, and bulltongue, Sagittaria sp., begin replacing the brackish-intermediate vegetation (O'Neil, 1949). However, cattle grazing, crop farming (rice) and marsh burning have interfered with much of the natural succession of the Chenier or prairie marsh. Much the same plant distribution occurs along the Chenier today.

> "Where the marsh has been heavily grazed by cattle, bulltongue, pickerelweed, Pontederia cordata, and delta potatoe grow very well. Coffee beans, Sesbon emerus and Daubentonia longifolia, often completely dominate the zone when encouraged by heavy grazing and favorable weather conditions. Wild mullet, Echinochloa crusgalli, is successful, provided a light drought prevails during the spring or early summer" (O'Neil, 1949).

Fresh marsh encompasses several major water bodies including Grand Lake, volume: 147,194 acre feet, and White Lake, volume: 234,182 acre feet (Figures from Perrett et. al., 1971).

Although frequently the furthest removed from the Gulf of all marsh zones, fresh marsh approaches within several miles of the coast beyond highway 27-32, east of Cameron, and extends inland for over 25 miles into Vermilion Parish. It is crossed by the Intercoastal Waterway for a distance approaching 50 miles (Chabreck, Joanen, Palmisano, 1968, map).

Fresh marsh in the abandoned delta is situated along the edge of the Mississippi River Alluvial Plain. It includes much of the upper bayous and the fresh floating marshes of Terrebonne, Charles, St. Mary and Jefferson Parishes. Maidencane, or paille fine, Panicum hemitonon, may dominate the vegetation in the old delta (Palmisano, 1971). This species, also called canouche, in time develops highly buoyant root mats, and is the basis for the formation of floating or "tremblant" marshes.

The modern Mississippi delta fresh marshes, are dominated by plant associations of roseau cane, Phragmites communis, and alligatorweed, Alternanthera philoxeroides (Palmisano, 1971). Chabreck (1972) estimated that 74,929 acres of fresh vegetation cover the central delta despite its proximity to the highly saline Gulf. For its survival, the fresh marsh depends on Mississippi River water which penetrates the delta through an estimated 16,840 miles of streams, canals and river channel (from figures of Becker, 1972).

Of the two dominant plant species of the delta marsh, roseau and alligator weed, the latter is considered a pest species. This plant established itself in the area around 1900, and by 1949, O'Neil had stated that alligatorweed had "...practically dominated hundreds of square miles of water, marsh and comparatively high ground in the fresh marshes of the delta." The plant currently accounts for 5.34% of all fresh vegetation in the coastal marshes and is the dominant species in both the Chenier and the delta (Chabreck, 1972; Palmisano, 1971). Since the plant is made up of about 95% water, its peat building qualities are practically nil and it is of little food value to waterfowl. "The peat usually formed by alligator grass is only a building mass of thick debris" (O'Neil, 1949). It is suggested that the plant might promote deterioration of the delta because it wilts during winter and succumbs to bacterial infection in the summer, yet crowds desirable species at other times of the year.

Thick stands of roseau cane are considered viable competitors with the weed. Roseau comprises 2.54% of fresh vegetation in the entire coastal marsh (Chabreck, 1972), most of it in the delta.

In his compilation of plant species for the entire fresh marsh zone, Chabreck (1970) listed 93 plant species, 170 percent more species than are found in intermediate marshes.

This greater diversity of plans may increase environmental complexity by providing more niches for additional plants and animals.

The dominant species for the entire fresh marsh was paille fine which comprised 25.6% of the vegetation. Local dominants have previously been reviewed in their respective regions. Chabreck (1970) listed as major species bulltongue Sagittaria falcata, spikerush Eleocharis sp., and alligatorweed Alternathera philxeroides. Secondary species included wiregrass Spartina patens, roseau cane Phragmites communis, (considered a delta dominant by Palmisano, 1971) and duckweed, Lemna minor. Minor species (1-2% of the vegetation) included water hyssop Bacopa monnieri, coontail Ceratophyllum demersum, water hyacinth Eichornia crassipes, water pennywort Hydrocotyle umbellata, Eurasian water milfoil Myriophyllum spicatum, cattail Typha sp., horned bladderwort, Utrianlaria cornuta, deep pea Vigna repens, giant cutgrass Zizaniopsis miliaceae, southern maiad Najas guadalupensis, white waterlily Nymphaea sp., and Cyperus oderatus.

Unlike much of the saltmarsh vegetation such as oystergrass which is not directly utilized as food by waterfowl, the plants of the fresh marsh are nutritional staples for both resident and migratory birds.

Situated at the southern end of the Mississippi Flyway, the Louisiana fresh marsh is the preferred habitat for large numbers of overwintering

waterfowl. Flocks of blue geese, Chen coeralescens, can denude the patches of three-cornered grass and cattail vegetation in the delta marsh (O'Neil, 1949). Geese and mallards prefer grain such as Walter's millet and rice; waterfowl widgeon, diving ducks and coots eat submerged vegetation, coontail, Eurasian water milfoil, horned bladderwort and southern maiad (Lynch, 1967). Of course waterfowl are not restricted to the fresh marsh. The mallard, or French duck, feeds on marsh grass and submerged eelgrass, a species found in saline waters (Louisiana Wildlife Education Bull. 71). Fresh marsh serves as a valuable habitat for nutria, raccoon and other furbearers, although the muskrat is more plentiful in the three-cornered grass brackish marsh.

5. Barrier Islands

Barrier islands are the remnants of abandoned Mississippi River deltas which protect the low lying coastal marshes from the turbulence of the open Gulf of Mexico. There are three prominent groups of such islands along the Louisiana coast: (1) the Chandeleur Islands, (2) Grand Isle and Grande Terre Isle, and (3) Isles Derniere and the Timbaliere Islands.

The flora of the barrier islands is a microcosm of the Louisiana marshlands. Beach and dunes, fresh and salt marsh, sand flats and interior plant associations are all represented. A summary of plant communities for the islands is given in Table 24.

The Chandeleur Islands form a chain nearly 50 miles long, but less than 2 miles wide, on the eastern boundary of the State of Louisiana. They extend from the Mississippi Sound in the north to Breton Sound in the south and buffer the wave activity of the Gulf from the old St. Bernard Delta. The Chandeleur Islands are separated from the mainland by the 40 mile wide, shallow Chandeleur Sound. The Mississippi River Gulf Outlet shipping channel has been dredged between North Point Island and Gosier Island near the south end of the chain.

The Chandeleurs, which have also been designated the Breton Wildlife Refuge, include large areas of salt marsh on their landward side.

Table 24 . Plants of the Barrier Island complexes, Louisiana. (From U.S. Army Corps of Engineers, 1973, Lemaire, 1961). Common species are listed first. Rare and uncommon species are not listed.

ISLAND	ZONE	COMMON NAME
Chandeleur Islands	Beach outer limits	------------
	Beach inward from the Gulf ...	sandspur
		sea rocket
		sea blite
		sea purslane
		love grass
	Beach further inland from the Gulf ...	beach morning glory
		wiregrass
		dropseed
		evening primrose
	Dunes ...	wild bean
		panic grasses
		sea oats
		Spanish bayonnet
	Dunes further inland ...	finger grass
		sedge and bindweed
	Interior shrub ...	wax myrtle (dominant)
		Eastern baccharis
		rattlebox
		deer pea
		croton
	Interior understory shrub ...	gerardia
		common ragweed
		prickly pear cactus
		sabatia
	Interior open meadows ...	love grass
		bermuda grass
		paspalum grass
		panic grass
		fox-tail
	Sand flats ...	water pennywort
		sandspur
		dropseed
		bulrushes
		sedges
		saltmarsh grass

Table 24.continued.

ISLAND	ZONE	COMMON NAME
Chandeleurs	Fresher marsh ...	sedges
		St. Augustine grass
		saw grass
		spikerush
		three cornered grass
		roseau
	Saltmarsh ...	black mangrove (dominant)
		oystergrass
		saltgrass
		wiregrass
		black rush
		batis grass
	Marine sperm-atophytes ...	shoal grass
		turtle grass
		manatee grass
		Halophila (2 sp.)
	Algae ...	Epiphytic and marine; brown, red, blue-green and green species.
Grand Isle- Grande Terre Islands		
	Beach and dune ... inward from the Gulf	goats foot morning glory
		wiregrass
		evening primrose
		sea oats
		water pennyroot
		croton
		Batis
	Meadows ...	sea oats
		goats foot morning glory
		dewberry
		broomsedge
		sedge
		sandspur
		foxtail
		fingergrass
		love grass
		water hyssop
		chaffweed
		spike rush
		widgeon grass and
		sand spurry, among other species.

Table 24 continued.

ISLAND	ZONE	COMMON NAME
Grand Isle - Grand Terre Islands		
	forest ...	live oak (overstory)
		persimmon
		prickly ash
		honey locust
		hackberry
		yaupon (understory)
		lantana
		white mulberry, among other species.
	Marsh ... (brackish)	three cornered grass
		wiregrass
		Fimbristlylis
	Marsh ... (salt)	black mangrove
		oystergrass
Timbalier, East Timbalier and Dernieres Islands		
	Beach outer limits	-----------
	Beach inward from the Gulf ...	goats foot morning glory
		sea oats
		water pennywort
	Dunes ... (low)	same species predominate as inward beach area.
	Flat meadows ..	grasses
		sedges
		herbs
	Interior shrub .	wax myrtle
		easter baccharis
		black mangrove (Isles Dernieres)
	Marsh ... (fresh to brackish)	wiregrass
		Fimbristylis
		three cornered grass
	(salt)	oyster grass
		wiregrass
		saltgrass
		black mangrove
		glassworts.

However, the Gulf coast of the island chain is beach and dune backed by interior shrub and sand flats. Fresh, brackish and salt marsh follow in sequence as the Chandeleur Sound is approached. Seagrasses cover much submerged area on the landward shore of the island.

Grand Isle and Grande Terre Isle form a barrier on the southern part of the Modern Delta between the Gulf of Mexico and the nearby La Fourche Delta. The island complex is approximately 15 miles long and nearly connects the salt marsh along the modern Mississippi Delta with that of Bayou La Fourche. These barrier islands are separated from the mainland by the very shallow (3-7 feet) Barataria and Caminada Bays. These two islands are separated by the Barataria connection to the Intracoastal Waterway. The Grand Isle chain has a more complex vegetational distribution pattern, probably due to its proximity to the mainland. Salt marsh covers the northern part of the Grande Terre Island along Barataria Bay. The southern corner of Grand Isle is beach followed by dune with meadow and forest spread through the center of the islands.

The third group of true barrier islands are the Isles Derniers, Timbalier Island and East Timbalier Island. These islands are remnants of the old Teche and La Fourche Deltas and are separated

from the mainland by Caillou Bay, Lake Pelto, Terrebonne and Timbalier Bays respectively.

The Dernieres-Timbaliers are largely saltmarsh on their landward sides with a wide beach along the Gulf. These beaches average out 100 feet wide and are backed by dunes raising 3-5 feet (U.S. Army Corps of Engineers, 1973).

The Isles Dernieres are a series of six or more barrier islands totalling 5,400 acres.

They are largely saltmarsh (70% of the Island's area is such) with a wide sandy beach dune on the Gulf of Mexico side (U.S. Army Corps of Engineers, 1973). Of the remaining land areas, 30% is beach and dunes (U.S. Bureau of Sport Fisheries and Wildlife, 1970). The dunes are covered with saltmeadow cordgrass Spartina patens, saltgrass Distichilis spicata, threesquare Scirpus americanus, two morning glories, sea ox-eye, love grass, sea pine, lippia, croton and minor species.

Waterfowl use is light. A few puddle ducks use the ponds and diving ducks, mainly scaup, are abundant in bays and sounds.

According to a study by the U.S. Bureau of Sport Fisheries and Wildlife (1970), the most important wildlife use is by herons and egrets. This study records the following distribution of nests on nearby Raccoon Island:

Bird	Nests
Louisiana heron	1,500
Snowy Egret	900
Black-crowned night heron	600
Common egret	600

Two roseate spoonbills, several yellow-crowned night herons, and three reddish egrets were seen during three visits to the islands.

Nesting colonies of gulls and terns were also counted in the Bureau of Sport Fisheries and Wildlife study:

Bird	Nests
Laughing gull	1,000
Royal tern	200
Sandwich tern	300
Black skimmer	200

The gulls and tern colonies were located on the small island east of Coupe Colin Pass. The laughing gulls nest primarily in the saltmeadow cordgrass and love grass covered dunes. The skimmers and terns nest on the highest bare sand and shell ridges. Several hundred least terns nest in loose colonies on the sand beaches of the islands.

Thousands of shorebirds gather on the mud and sand flats of the islands in the spring, fall and winter. Willet and clapper rail are nesting residents.

According to this study, frequent flooding of the island precludes successful population by more than a few raccoon, muskrat, nutria and cotton rats.

The beaches of the barrier island complexes may be classified as high energy beach communities. Figures 25 and 26 represent typical jetty and high energy beach communities.

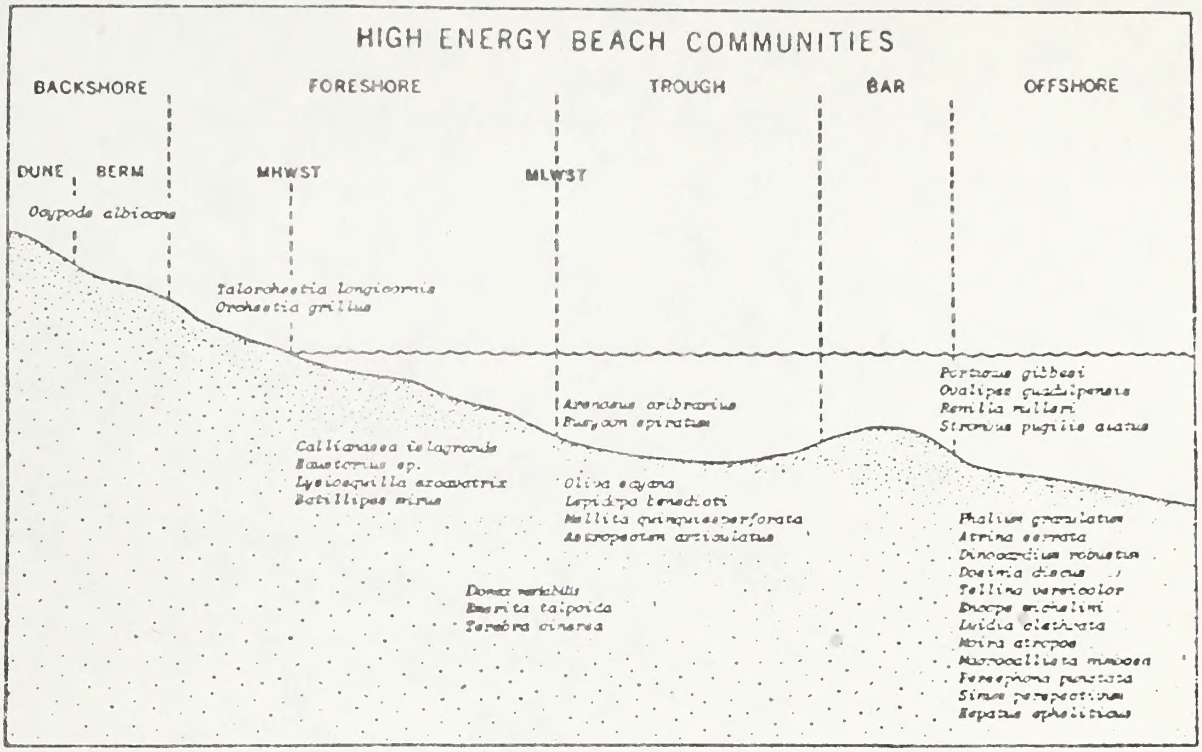

Figure 25. Composition of these communities are essentially the same for the Louisiana Barrier Islands and Chenier coast (from Collard and D'Asaro, 1973).

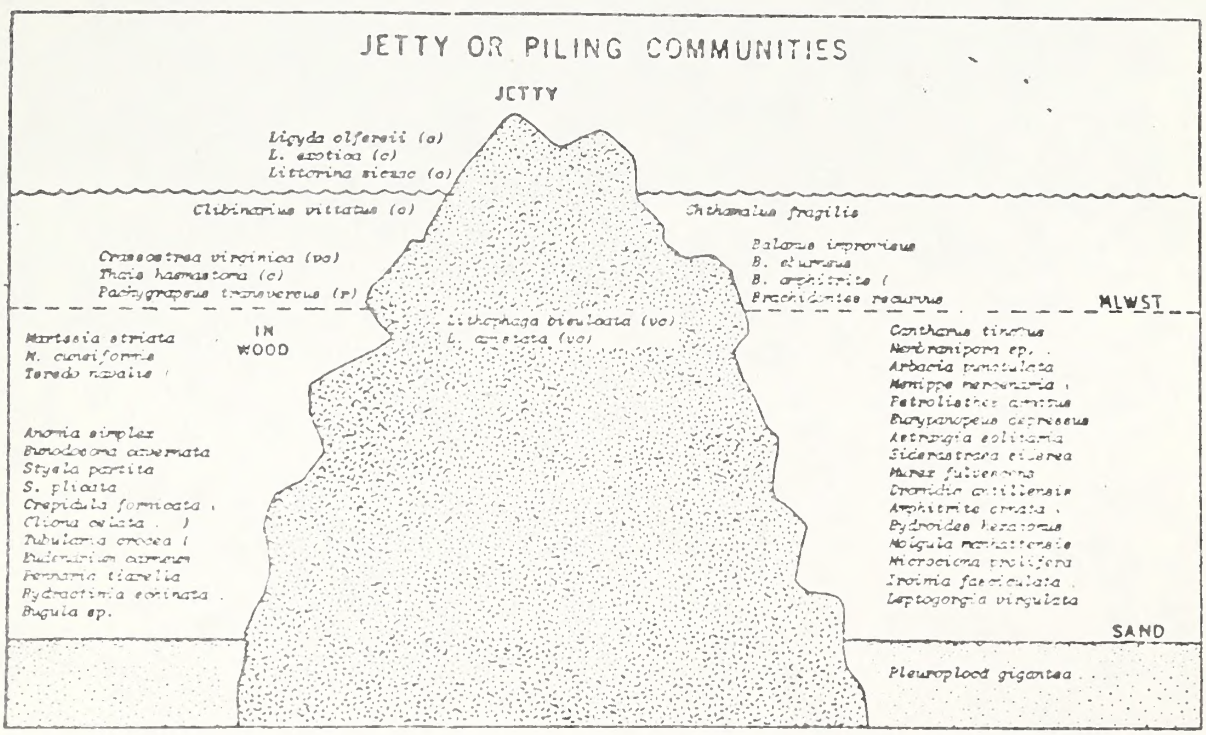

Figure 26 Carolinian affinities. Common in northeastern Gulf Coast. (Collard and D'Asaro, 1973).

6. Fauna of the Marshes and Barrier Islands

The fauna of the Louisiana coastal zone is composed of amphibians and reptiles, birds and waterfowl, and mammals. Fishes and aquatic invertebrates of the marsh will be discussed in a later section on the estuaries and embayments of the coastal zone.

There are 130 species of amphibians and reptiles in coastal Louisiana (Conant, 1957). These include 18 species of salamanders, 27 species of frogs and toads, 29 species of turtles, 13 species of lizards, 42 species of snakes, and the American alligator. These animals are distributed in the marsh according to suitable habitat and food availability and are all components of the marsh food web. The terrestrial and aquatic amphibians feed on worms, snails, arthropods, and small molluscs. Most of them eat only moving prey. Frogs and snakes are primarily insectivorous while lizards and snakes (Order Squamata) consume insects as well as small mammals. Sea turtles and land tortoises (Order Testudinata) are carnivorous as well as herbivorous, eating small fish or insects, and plants and berries as appropriate to their natural habitat. The American alligator is a top carnivore in the food web (Hickman, 1961). Species abundance in this food web increases with the greater plant diversity in the fresher marshes.

Alligator

The American alligator, Alligator mississippiensis, is the only endangered reptile in Louisiana with the possible exception of some sea turtles, and primarily inhabits the fresh and intermediate marsh vegetational zones. Alligators inhabiting brackish marsh water holes during drought periods must tolerate fairly high salinities, a condition which inhibits the growth of their young. In controlled experiments, the Louisiana Wildlife and Fisheries Commission (1971) showed that six newly hatched alligators kept in salinities of 0 ppt and 5 ppt gained weight over a 2 month period while another six which were kept in salinities of 10 and 13 ppt lost weight during this same time period. One alligator of the 13 ppt salinity group died in an emaciated condition in 68 days.

During the drought season in the southeastern marshes of the state, an alligator will dig a hole for itself up to 20 feet in diameter. This hole also provides water for furbearers, wading birds, waterfowl, and deer. The water hold then becomes a feeding ground for the inhabiting alligator. Food preferences of the alligator include the blue crab, snakes, turtles, nutria, raccoon and muskrat, and some unwary birds (Louisiana Wildlife Bulletin No. 55).

The largest alligator populations reside in the Chenier marshes of the state where populations approach the density of one alligator per 10 acres of habitat. An estimated 250,000 alligators reside in the Louisiana coastal marsh exclusive of those living in swamps (Louisiana Conservationist, 1972). The Bureau of Sport Fisheries and Wildlife recorded 4,460 alligators as residents of the Federal refuges (Threatened Wildlife of the United States, 1973). Because of an expanding alligator population, an experimental alligator season was authorized for 1973 to include Cameron and Vermilion Parishes (Louisiana Wild Life and Fisheries Commission News Release #216, 7/31/73). Preliminary results of this experimental program of alligator harvesting in 1973 indicate that 2,916 alligators were harvested for an estimated value of $268,542.00 or $14.00 per foot (Joaner, McNease, Linscombe, 1973).

Birds

Birds and waterfowl may inhabit the Louisiana coastal marsh for all or part of their lives. Resident species such as the willet, *Catroptrophorus semipalmatus*, rarely leave the marshes while others such as the blue goose, *Chen coerulescens*, Canada goose, *Branta canadensis*, and common mallard, *Anas platyrhynchos* migrate great distances. Some birds such as the buff-breasted sandpiper, *Tryngites subruficollis*, migrate through the area. The herring gull, *Larus argentatus*, which migrates to the Louisiana beaches

during the winter, spends much of its time seeking food from the Gulf and frequents the shore to nest. In addition to the fishing birds, there are insectivorous species, and those that prefer marsh and submerged vegetation. The coastal marsh ecosystem includes wading birds, diving and dabbling waterfowl. A checklist of southern Louisiana birds records 292 species (Lowery, 1960).

The white ibis, a wading species, is common throughout the coastal areas and is most highly concentrated in the zone of intermediate Chenier marsh (Palmisano, 1971). In 1971 there were 31,680 of these birds in this marsh zone, 65% of all coastal white ibis in south-western Louisiana (Palmisano, 1971). No white ibis were found in the coastal salt marsh zone in December of 1970 or February of 1971, the times of the study. Mid-winter waterfowl estimates for the Louisiana coastal marsh during December 1972 compiled by the Louisiana Wild Life and Fisheries Commission included 4,374,000 ducks of which 84% were dabblers. In order of decreasing species abundance these were the Gadwall, _Anas strepera_, Green-winged teal, _A. carolinensis_, baldpate, _Mareca americana_, pintail, _Anas acuta_, mallard, _A. platyrhyncos_, shovellers, _Spatula clypeata_, and mottled duck, _Anas fulvigula_. The remaining 16% of the waterfowl surveyed were diving ducks: greater and lesser scaup, _Aythya marila_ and _A. affinis_, ringnecked, _A. collaris_, hooded meganser, _Lophodytes cucullatus_, ruddy, _Oryura jamaicensis_, redhead, _Aythya americanas_, and canvassback, _A. valisineria_.

The principal Louisiana birds and their food and nesting habits have been summarized in Table 25. This table was compiled from Day, et al. (1973) and Pearson (1936).

The relative densities of birds in a representative Louisiana estuary, Barataria Bay, was given in terms of biomass by Day, et al. (1973). Sparrows, wrens, and similar birds were present in greatest quantity of biomass, and were followed by wading birds, rails, ducks, and shore or fishing birds as illustrated in Table 26.

Table 26 Average Annual Biomass of Different Groups of Birds in the Saline Area of Barataria Bay

(From Day, Smith, Wagner & Stove, 1973)

Trophic Group		Biomass (g dry wt/m^2
Ducks		0.0063
Wading birds		0.0106
Sparrows, wrens, etc.		0.0118
Rails		0.0099
Shore birds and fishing birds		0.0054
	Total =	0.044

The seasonal abundance of the various birds is indicated in Figure 27. According to Day (1973), who based much of his information on Lowery (1960), shore birds are more abundant in the saltmarsh during colder months and feed on the small invertebrates and crustaceans on the mudflats. Terns are more abundant during

Table 25. Food and Nesting Habits of Principal Estuarine Birds of Louisiana 1/

Species	Food/forage	Nesting Habits
(Wading Birds)		
Great Blue Heron *Ardea herodius herodius*	minnows 67% shrimp & crabs 10% small mammals 5%	in tall trees (i.e., cypress) along river banks
Little Blue Heron *Florida caerula*	fish 27% crustaceans 45% insects 16%	in trees or bushes near swamps
Louisiana Heron *Hydranassa tricolor ruficollis*		in mangrove or willow swamps in communities with other herons
American Egret *Herodias egretta*		platform of sticks in mangrove or trees; salt or brackish environments
Snowy Egret *Egretta candissima candissima*	small fishes crustaceans, snails, insects	in mangroves in swampy willow ponds
Cattle Egret	mostly insects	
White Ibis *Guara alba*	crustaceans 60% fish 13% snails 13% insects 13%	mangrove thicket of twigs from the mangrove
Wood Ibis *Mycteria americana*	crustaceans, insects (Palmer, 1962)	platform of sticks in trees sometimes 100 feet up
White-faced Ibis *Plegadus guarauna*		reed beds constructed of dead reeds attached to the upright stalks of living ones

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Taken mainly from Day, J. W., W. C. Smith, P. R. Wagner, and W. C. Stowe. 1973. Community structure and carbon budget of a salt marsh and shallow bay estuarine system in Louisiana. Sea Grant Publication No. LSU-SG-72-04. Louisiana State University, Baton Rouge, Louisiana.

Table 25

Species	Food/forage	Nesting Habits
(Waterfowl)		
-Puddle ducks-	68% plant 29% molluscs 3% crabs 31.5% animal	
Shoveler Spatula clypeata		located in the marshes or in dry grass or under bushes; constructed of grass or leaves, and lined with feathers or down
Gadwall Chandelasmas strepenis		slight hollow in a bunch of grass or reeds usually near water - dry grass lined with down feathers
Pintail Dafila acuta		on the ground usually in tall bunders of prairie grass, near the water; made of dry grass, snugly and warmly lined with down
Widgeons i.e., the Baldplate Mareco americana		on the ground in marshes; a neat well built structure (for a duck) of grass and weeds; lined with featers and down from the breast of the bird
Mallard Anas platyrhychos	75.2% plant 24.8% animal: snails 11% insects 4% fish 2% (Martin & Uhler, 1939)	ground in tussock of grass or weeds; built of fine reeds, grass or leaves line with down

Table 25.

Species	Food/forage	Nesting Habits
Mottled duck Anas fulvigula maculosa	75.2% plant i.e., rice/ryegrass 24.8% animal: snails 11% insects 4% fish 4%	on the ground, a large rather well made structure of weeds and grass with a deep cup; lined with down and feathers
Blue Winged Teal Querquedula discors		marshes on dry ground; constructed of grass and weed stems and lined with feathers and down
Green Winged Teal Nettion carolinense		on ground in thick growth of grass or among willows; constructed of dry grass; lined with feathers or down
-Diving Ducks-		
Lesser Scaup Marila affinis		similar to scaup (in marshy ground made of weeds, grass lined with down
American merganser Mergus americana		in hollow tree on ground, in crevices of rocks, constructed of moss, leaves, grass and warmly lined with down
Hooded merganser Lophodytes cucullatus		in hollow trees lined with grass leaves
-Coots-		
Fulica sp. Fulica americanus		dead reads, grasses, luts of decayed vegetation afloat on the water or in the reeds

Table 25.

Species	Food/forage	Nesting Habits
Redheads *Marila americana*		on ground near water or in a clump of dead reeds over the water; bulky but well constructed and lined with down
(Fishing Birds)		
Herring Gull *Largus argentatus*		sometimes on the ground, occasionally in trees, ground nests usually mere depressions with scant nesting material
Laughing Gull *Larus atricilla*		on the ground in the marshes; constructed of seaweed, sedges; eelgrass
Ring Billed Gull *Larus delawarensis*	minnows and open water fish	
Foresters Tern *Sterna forsteri*	shrimp	in marshes constructed of dead reeds and stems of water plants and lined with finer reeds
Royal Tern *Sterna maxima*		a hollow in the sand
Least Tern *Sterna antillarum*		in a pebbly depression on the dry sand of beaches
White Pelican *Pelecanus erythrorhychos*	fish (Palmer, 1962)	on the ground; constructed by the bird scraping the sandy soil into a heep 1/2 foot high and erecting a shallow platform of sticks at the base
Black Skimmers *Rychops nigra*		sand/sand-shell

Table 25.

Species	Food/forage	Nesting Habits
(Shore Birds)		
Plovers -family Charadriidae Squatarola squatarola		slight depression in the mass or ground sometimes lined with grass and leaves
Willets i.e., Catoptrophorus semipalmatus semipalmatus	snails, crustaceans and other animals of mudflats and bare areas in mudflats	tussock of grass or weeds, close to the water, in trash or saltwater marshes, a carelessly built structure of small reeds and grass
Sandpipers family Scolopacidae	snails, crustaceans and other animals of mudflats and bare areas of mudflats	most species a hollow in the ground near saltmarshes or fresh-water loker and ponds
Rails family Rallidae	crabs, snails, insects (Bateman, 1965; Oney, 1954)	on the ground may be in marsh grass, built of reeds and grass, well concealed from above by interlacing of surrounding grass
Sea side sparrow Passerherbulus Maritimus maritimus	insect and plant material	nests are laced in areas of fine marsh grass, usually beneath dead drift patches of grass above normal high water mark (many nests are destroyed every year by extra high tides), constructed almost entirely of dried grass, lined with finer blades
Wrens family Troglodytidae		cavities in trees, dome shaped nests

Table 25.

Species	Food/forage	Nesting Habits
Blackbirds and Grackles <u>Agelarius</u> <u>phoeniceus</u> <u>phoeniceus</u> families Icteridae		found in bushes, small trees or reeds interwoven between the outside layer of sedgegrass of which the nest is composed, sometimes in the center of a tussock close to the ground but usually 2 to 3 feet above it, always in swampy places
Woodcock <u>Philohela</u> <u>minor</u>		on ground; on brushy bottoms or in open woods, usually not far from water; a depression in the leaves without lining

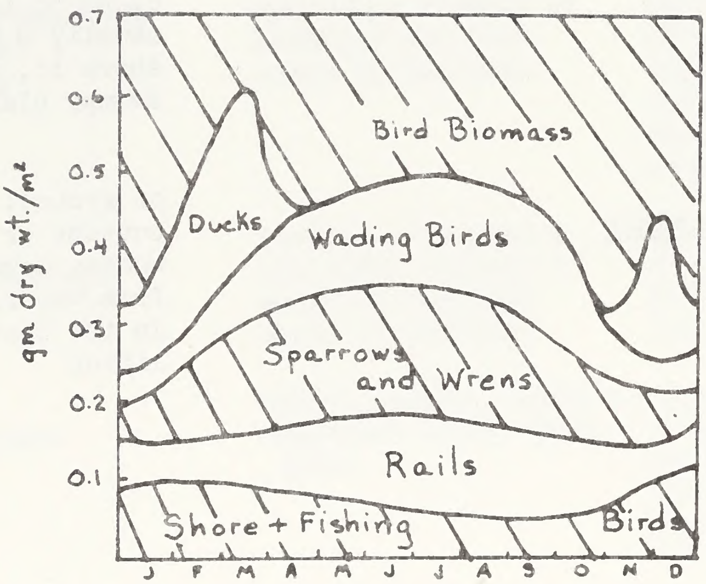

Figure 27. Pattern of population and biomass of birds in the saltmarsh (Day <u>et al</u>, 1973). Based on data on ducks from Bateman (1971) and data on wading birds from Bateman (1971), Newsom(1971) and Lowery (1960, 1971).

the summer and gulls are more prevalent during the winter. White pelicans migrate into the coastal areas during the colder months. wading birds are present in the summer but migrate into Mexico during the colder months. Ducks migrate into the coastal marshes in great numbers during the fall and most least by late spring. Mottled ducks are permanent residents.

Ducks constantly move into and out of the Louisiana marshes at various times of the year. Referring to the movement of waterfowl in the marshes of Louisiana, Day, et al. (1973) says:

> "There is also considerable internal movement by all waterfowl within the marsh areas as habitat conditions are changed by rain, tides, and other factors. For example, local weather conditions and food availability constantly influence the number of lesser scaup found in the salt marshes along Louisiana's coast. Louisiana's coastal scaup population often remains in offshore, Gulf waters for the entire winter, but in some years reduced food availability, weather, or other factors require many of these diving ducks to move into shallow bays and salt marsh ponds."

Four species of birds which inhabit the Louisiana coastal marsh are included in the publication "Threatened Wildlife of the United States" (Bureau of Sport Fisheries and Wildlife, 1973). Threatened species include:

- Eastern brown pelican, *Pelecanus occidentalis carolinensis*
- Southern bald eagle, *Halieetus lencocephalus*
- Arctic Peregrine Falcon, *Falco peregrinus tundrius*
- American Ivory-Billed Woodpecker, *Campehilus principalis principalis*

Mammals

Mammalian fauna in the southern Louisiana marsh includes the furbearers and the sports game. These animals are distributed throughout the four marsh zones according to the availability of preferred foods and habitat protection.

The primary furbearers of the marsh include the muskrat, Ondantra zibethicus rivalicius, nutria, Myocaster coypus, raccoon, Procyon lotor varius, mink, Mustela vison and otter Lutra canadensis.

Most muskrats live in the brackish marsh zone where they prefer to feed on the tubers and roots of three-cornered grass which grows all year. In the brackish sub-delta marshes a study of plant usage indicated that three-cornered grass was used 80% of the time, wiregrass-10%, hogcane-5% with the remaining 5% a combination of 10 plant species and remnants of mollusks. In the delta marshes which lack significant amount of three-cornered grass, muskrats consumed cattail 70% of the time, alligator weed-15% and three minor plant species and invertebrates-15%. In the brackish marsh of the Chenier, these mammals consume three-cornered grass 70% of the time, leafy three-cornered and wiregrass 10%, hogcane-10% and 12 other plant species-10%.

The food requirements of the muskrat are tremendous. Weighing an average of two pounds, the Louisiana muskrat consumes a third of its weight in grasses a day (Svihala in O'Neil, 1949). One large

muskrat consumes the food supply of a square foot of three-cornered grass or wiregrass in the marshes. It daily consumes at least twice that amount of any other grass. Observations by Day, et al. (1973) indicated that muskrats mainly eat the roots rather than the above ground portion of the plants. While the muskrat is primarily a herbivore, it will occasionally eat animal matter.

Flooding of the marshes by the Mississippi River replenishes the nutrients utilized by the grasses upon which the muskrat heavily feeds. According to Ted O'Neil, Fur Division Chief, the influx of river waters during the 1973 flooding season supplied these nutrients to improve marsh conditions. High water also caused taller grasses to die off allowing younger vegetation to blanket the marsh making an ideal habitat for furbearers (Louisiana Wild Life and Fisheries News Release, 8/16/73).

Muskrats dwell in houses they construct from marsh grasses, shrubs and available stumps. The house ranges in size from 3 to 6 feet in diameter at the base and 2 to 4 feet in height. The structure contains an average of 4.5 animals. Such houses protect the furbearers from tides and changing temperatures.

The muskrat is the second leading producer of the fur pelts in Louisiana. Nutria is the highest producer. During the 1972-73 fur trapping season in the State, 346,787 muskrat pelts were taken for an increase of 20,274 pelts over the number the previous season

(1971-72). These pelts were valued at $1,430,497. Sale of muskrat meat accounted for another $24,000 (Louisiana Wild Life and Fisheries Commission, Fur Division, 1973).

Nutria was introduced into the coastal marshes from Argentina in 1937 and has since experienced a phenomenal growth in population. The animal weighs 18 to 25 pounds and is about the size and shape of a beaver except the nutria has a round tail. Although it is only 1/5 as populous as the muskrat in Louisiana, it is the primary producer of fur pelts there.

In its invasion of the marshes, nutria have affected both obvious and subtle changes in the ecosystem. These include "eat-outs" 1/, land loss, channelization and other marsh deterioration. Unlike the muskrat which prefers to feed on the three-cornered grass of the brackish marsh, the nutria consumes large quantities of fresh marsh plants such as alligator weed, cattail, bullwhip, cutgrass, delta duck potato, fresh water three-cornered sedge among other species. In brackish marsh, nutria feed on three-cornered sedge, wiregrass, leafy three square and hogcane.

Nutria have colonized both the marshes and uplands of Louisiana. In the 1972-73 fur trapping season, 1,611,623 pelts were taken

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1/ "Eat-out" - The nearly complete removal of vegetation, including root systems from a marsh by a large number of plant consuming animals such as muskrat or nutria. The result of such an "eat-out" is a large pond of mud and water which is extremely difficult for plant communities to recolonize.

having a total estimated value of $6,737,744. These figures reflect an increase of 325,001 pelts over the previous season.

The raccoon inhabits coastal as well as upland regions of the State. The coastal raccoon is an omnivorous animal that consumes other small mammals and birds, in addition to marsh plant growth. According to Day, et al. (1973), fruits are the principal plant foods of the raccoon. In summer and fall, the raccoon feeds on plants more heavily than in winter or spring. Raccoon fecal pellets collected around Airplane Lake, Louisiana were composed of 80% fragments from mollusk and crab shells. The marsh diet of raccoons probable includes plant material, crabs, snails, fish, birds eggs, and mussels (Day, et al., 1973). Trapping of raccoons brought 49,274 pelts in the 1972-73 season having an estimated value of $221,733.

Mink primarily inhabit the swamps and fresher marshes of Louisiana (O'Neil, 1949) but is also found in the saltmarshes (Day, et al., 1973). A one year increase in harvest of 19,763 pelts were taken in 1972-73 for a total of 44,062 pelts valued at $264,372.

Otter is found in lakes, bayous, streams and all coastal marshes of Louisiana. The otter, like the mink, eats fish and crayfish of which there is a plentiful supply in Louisiana. Yet otter populations have remained comparatively small. A total of 7,688 otter pelts were taken during the 1972-73 trapping season for an increase of

2,228 pelts over the previous year. Value of the otter pelts was estimated at $322,056 (Louisiana Wild Life and Fisheries Commission, Fur Division, 1973).

Sports game in southern Louisiana include white tailed deer, Odocoilens virginianas, and bob white quail, Colinus virginianas, grey and fox squirrels, Scirus carolinensis, and S. niger.

Deer dwell in the lower Mississippi-Atchafalaya bottomland forest of the state. "In the southern section (of the state) cut-over cypress-tupelo swamps, mixed hardwoods on ridges in the swamps, and the wetter land type hardwoods made up the basic range (of the white tailed deer)" (Louisiana Wildlife Inventory, 1959).

Range of the squirrel also extends into the hardwood forest of the Lower Mississippi Alluvial Plain as well as the plains of other large rivers. This area, which comprises about 5,500 acres, may be the best producing squirrel range in the United States.

Quail inhabits both the bottomlands of alluvial plains and limited inland sections of the Chenier; however, the annual food supply is greatly disrupted by the flooding of rice areas. In addition, the lack of protective cover limits the growth of quail populations in the Chenier.

Black bears were introduced into the Atchafalaya bottomland forest and fringe marsh from 1964 to 1967. In this project of the Louisiana Cooperative Wildlife Research Unit of Louisiana State University, 130 black bears of all ages and sexes from near Cooke City, Minnesota, were trapped and transported to the Atchafalaya Basin. While some of these have migrated into adjoining areas, many have remained and now comprise a reproducing population. Hunting of these bears is prohibited by state law.

7. Seagrasses

The Mississippi River interrupts an otherwise continuous band of seagrasses which extends along the Gulf Coast from Florida to Texas. The turbid fresh water of the river adversely affects inshore seagrass beds as far southwest as Galveston, Texas (Humm, 1973). Louisiana seagrasses have been described near the Chandeleur Islands (Lemaire, 1961), and in the bay and estuaries of the deltas. However, most studies on seagrasses have concentrated on the grass beds of the eastern Gulf (Humm, 1973).

Seagrass is limited to waters where sunlight penetration permits photosynthesis. They are found in the shallow waters of bays and around islands in areas of low turbidity. Of the 647 plants recorded in the Gulf of Mexico, 329 occur from the shore to 10 m depth (Earle, 1972).

The most common species of seagrass in the Louisiana Gulf include turtle grass, manatee grass, shoal grass, and two species of Haliophila. Widgeon grass is found in the less saline waters of the coastal inlets and bays.

Turtle grass, Thalassia testudinum, is the most abundant species in the eastern Gulf where it may account for 60 to 75% of all seagrasses in terms of bottom cover (Humm, 1973). It is found north of the Chandeleur Islands, but is reported as being less common off the southern islands (Lemaire, 1961). It occurs from mean low spring tide level to a water depth of about 5-10 meters.

Manatee grass, Syringodium filiforme, grows throughout the Gulf in muddy sand at depths to at least 25 feet (Earle 1972). It grows in fairly pure stands and has been reported in the small island west of the Chandeleurs. Manatee and turtle grass frequently grow in association.

Halophila engelmani and H. baillonis generally occur in deeper waters although they may mix with other plants in shallower areas. The former species has been found in 220 feet of water, but rarely in a depth less than 3 feet (Humm, 1973). The latter species grows at somewhat shallower depths, and occurring in the northern Gulf at depths of 6 to 10 meters or more (Taylor, 1928). Both species have been observed growing on muddy bottoms in the Gulf (Earle, 1972).

Shoal grass, Diplanthera wrightii, occupies the most extensive geographic range of all seagrasses in the Gulf, and is the most tolerant of fluctuations in environmental conditions of any species in the Gulf. It is more tolerant to changing salinities than most other species and is found in the mouths of estuaries (Earle, 1972).

Widgeon grass, Ruppia maritima, is not a true seagrass, but grows in brackish areas. This species is a food source for many waterfowl.

The environmental role of seagrass has been thoroughly outlined by Humm (1973) as follows:

(1) They serve as a sediment trap, stabilizing bottom sediments from the waters edge to a depth of 6 to 16 meters or more.

(2) They carry on primary productivity that, in the eastern Gulf, may considerably exceed that of benthic algae or phytoplankton in the same area.

(3) They serve as a direct food source (fresh) for a few animals, including sea urchins, sea turtles, manatees, and certain herbivorous fishes; partially decomposed leaves in the form of detritus serve as a food for a wide variety of detritus-feeders, especially invertebrates but also some fishes.

(4) They serve as a refuge, and a source of food organisms as well, for juveniles of many species of seafood organisms including shrimp, crabs, bay scallops and fishes.

(5) They provide a habitat for a certain assemblage of invertebrate species that burrow or grow attached to the leaves; these organisms might otherwise be uncommon or absent in habitats that lack seagrasses.

(6) They provide an important substrate for attachment of scores of species and a significant biomass of benthic algae that otherwise would be rare or absent in an area.

8. Estuaries and Embayments

The Louisiana coastline surrounding the marshes of the abandoned and the modern Mississippi Delta is ringed by a series of embayments and estuaries which when measured in a straight line give Louisiana a 300 mile long coast from its easternmost boundary in the Chandeleur Islands to the western state line in the Sabine Lake. If all of the tidally-affected coastline is included, the length is in excess of 12,000 statute miles (Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana, 1971).

Major water bodies considered in this study along, with their respective acreage, are as follows: Chandeleur Sound, 578,003; Breton Sound, 195,330; East, West and Garden Island sounds surrounding the modern delta, 79,345; Barataria Bay, 43,551; Caminada Bay, 14, 158; Terrebonne and Timbalier Bays, 50,388 and 79,713 respectively; Caillon Bay, 27,085; Atchafalaya Bay, 134,679; East and West Cote Blanche Bays, 82,314 and 89,902 respectively; and Vermilion Bay, 121,604. Sabine Lake and Calcasieu Lake cover 55,858 and 42,792 acres each.

Estuaries and bays are highly productive ecosystems. They receive nutrients from upland areas via major river systems, especially during spring flooding. They also receive the nutrient wash-out from tidal flushing of the salt marsh, particularly in mid-winter when marsh grass of the previous season is decomposing. Figure 28 represents a simplified typical bay or sound ecosystem.

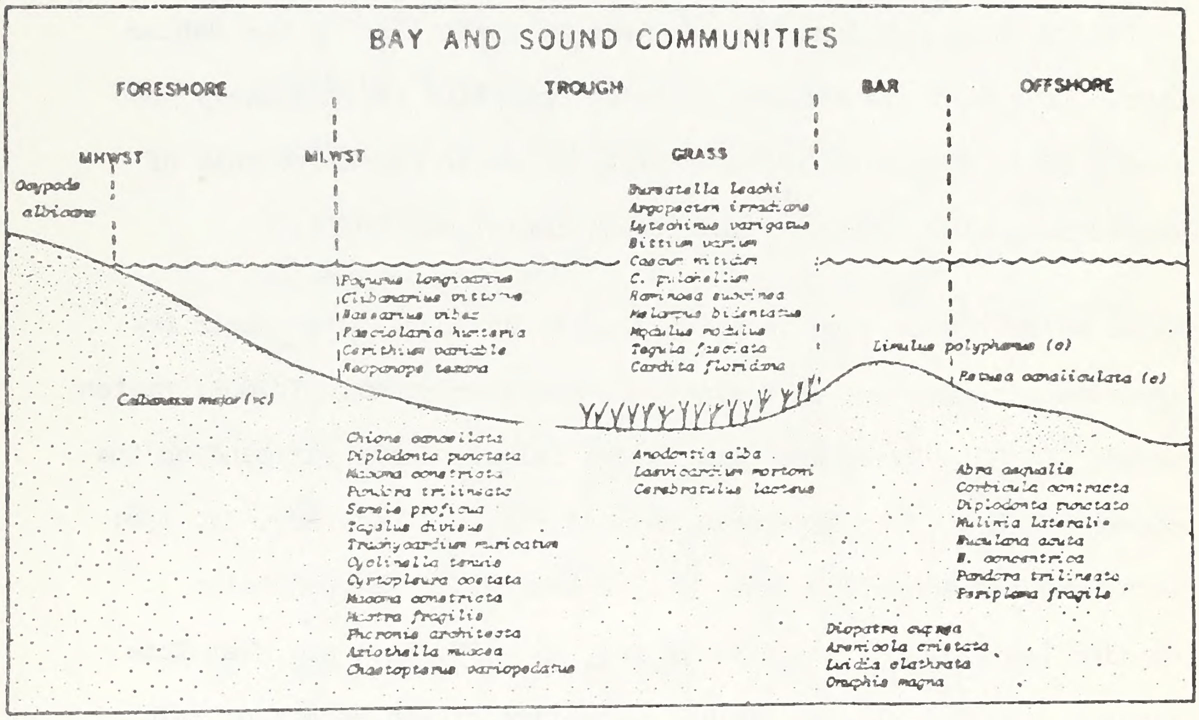

Figure 28 West Indian affinities. The greatest concentration of species occurs in the grass Thalassia testudinum or turtlegrass. (Collard and D'Asaro, 1973). While these communities predominate in the southeastern Gulf coast of Florida, they are also found in the turtlegrass growths of the Louisiana barrier islands.

In the Barataria Estuary, 58% of the total net estuarine production is used by species within its geographical confines while 42% is washed to offshore communities (Stone, 1972).

Primary production has been estimated for portions of Barataria Bay by the Center for Wetland Resources of Louisiana State University. It was shown that the types of producing organisms which contributed to the production of biomass varied on a seasonal basis. Phytoplankton production was at a maximum during July and at a minimum during the winter. Epiphytic 1/ production peaks during spring and late winter. Benthic algal production peaks during late August and early September. Production of oystergrass is highest during April and May and remains high during July.

At the simplest level, consumers of dead plant material (detritus) include the bacteria associated with benthic communities and sediments. In the majority of estuaries, the most important detritus feeding benthic animals are molluscs, mainly bivalves. The ciliary collection and sorting mechanisms of bivalves are particularly well suited to collecting the finer detritus suspended in the water or settled on the bottom. The same siphonal arrangements used for collecting food allow these bivalves to live within largely anaerobic bottom deposits while taking better oxygenated water from above. Bivalves such as the oyster, *Crassostrea virginica*,

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1/ Epiphyte - A plant that grows on another plant but is not a parasite and produces its own food through photosynthesis (Air plant).

and brackish water clam, Rangia cuneata, are common examples of such filter feeders.

In the brackish waters of Louisiana, the oyster lives in depths from 30 cm above mean low water level to 12 m below mean low water level in salinities ranging from 10 parts per thousand (°/oo) to 30°/oo (Stone, 1972). Oysters consume phytoplankton as well as detritus and live in "bars" or elevated communities where sufficient circulation provides a continual source of phytoplankton. Though they spend most of their juvenile and adult lives on the bar as sessile (non-locomotive) organisms, as larvae they swim freely in the water column for 3-4 weeks before settling as spat. An oyster reef is diagrammed in Figure 29.

The brackish water clam, Rangia cuneata, is found primarily in Lakes Pontchartrain and Maurepas but is distributed all along the Gulf Coast. This organism prefers less saline waters than the oyster and consumes both detritus and plankton. In turn, Rangia are eaten by the freshwater drum, Aplodinotus grunniens, and the black drum, Pogonias chromis

Penaeid shrimp, three species of which are of economic and ecologic importance in Louisiana estuaries, feed on detrital food particles. Young shrimp thrive best in waters of reduced salinity but adults

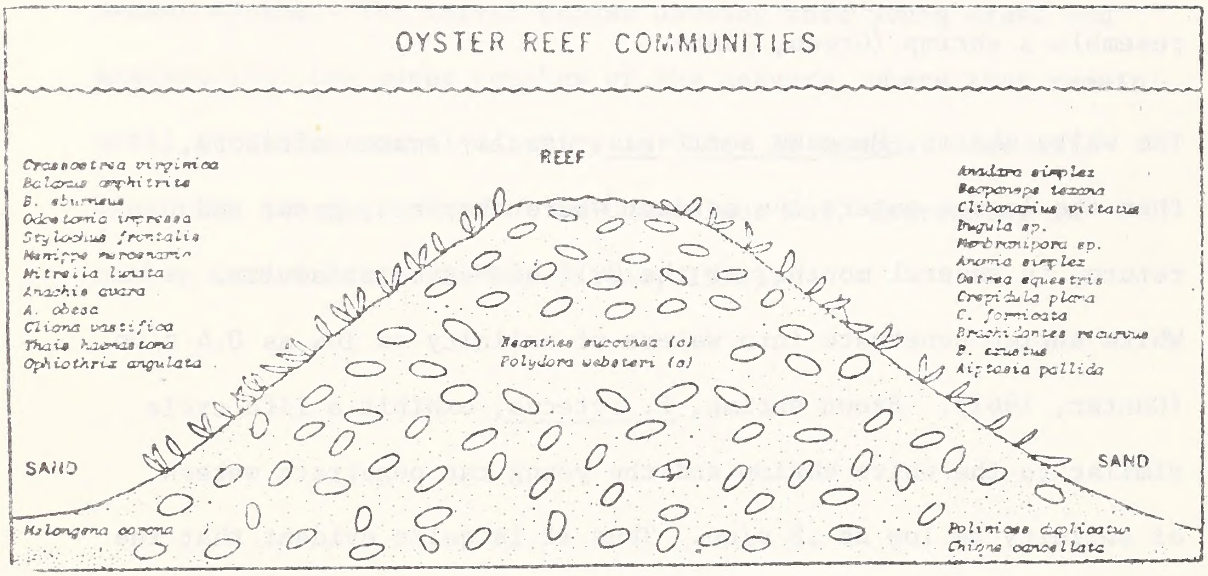

Figure 29 Carolinian affinities. Crassostrea virginica is the dominant species and is most successful at lower salinities. Predators, such as Thais haemastoma, and competitors, Ostrea equestris, are more common at higher salinities (Collard and D'Asaro, 1973).

migrate seaward to breed. The eggs may be freely shed in the sea or attached to the abdominal appendages of the female, and give rise to nauplius larvae. After passing through several months, the nauplii change to protozoea larvae which differ in morphology but swim like nauplii. After three months the protozoea larva transforms to a zoeal stage and begins to resemble a shrimp (Green, 1968).

The white shrimp, Peneaus setiferus, usually spawns offshore, then the larvae enters the estuary where they eat, grow, and return, in several months, to the Gulf of Mexico as adults. White shrimp penetrate into waters of salinity as low as 0.4 o/oo (Gunter, 1961). Brown shrimp, P. aztecus, exhibit a life cycle similar to the white shrimp and the young can penetrate waters of salinity as low as .8 o/oo. Thus it is quite evident that the shrimp could penetrate the inner most reaches of the brackish and intermediate marshes of Louisiana during their life cycle. The pink shrimp, P. duodarum, is not a major species of Louisiana estuaries but is found along the eastern Gulf and Atlantic Florida coast. This latter species is not as euryhaline 1/ as the other two and does not penetrate into waters of salinity less than 2.7 o/oo.

1/ Euryhaline - an organism having a tolerance for a wide range of salinity. (Sverdrup et al. The Oceans, p. 770).

A consumer of decomposing animal matter, the bluecrab, Callinectes sapidus, is a resident of the fresh and saltwater marshes of Louisiana for the entire year. According to Darnell (1959), mating occurs in waters of low salinity (below 20 o/oo), where the males remain, but the females then migrate into waters of higher salinity (above 20 o/oo) and remain there until the larvae hatch during mid-summer months. The larval stages develop into young crabs and migrate into the upper reaches of the estuary, where they remain until attaining sexual maturity in about 18 months. Juvenile bluecrabs are most abundant in Chandeleur Bay, decreasing in number toward Barataria Bay (Stone, 1972).

E. Biology of the Offshore Environment

1. The Environment

The continental shelf is defined physically as the zone extending from the line of permanent immersion around a continent to the depth where there is a marked or rather deep descent toward the great depths (Sverdrup, Johnson, and Fleming, 1942). The zone of steeper descent which extends from the shelf to the relatively flat oceanic depths (the abyssal plain) is the continental slope. While the natural break between shelf and slope is near 200 meters on a worldwide average, it occurs at a much shallower depth, 120 meters, in the northern Gulf of Mexico off Louisiana. This shelf break occurs approximately 125 miles offshore at the Texas-Louisiana border, and 10-20 miles off the Mississippi delta. For the purpose of discussion of the biology of the offshore environment, the landward margin of the continental shelf is functionally defined as the seaward edge of submerged seagrass beds. Where these beds are absent, it is assumed that the shelf begins at the line of total immersion or mean low water.

The offshore environment is broadly divided into the pelagic and benthic realms. The pelagic division includes all ocean water above the bottom; over the continental shelf, the waters constitute the neritic province (as opposed to the oceanic province above the slope and deep ocean bottom). The benthic division includes the sea bottom

and sub-bottom environment. Shoreward of the natural shelf-slope break, the benthic division is termed the littoral zone.

a. <u>The Neritic Province - Shelf Waters</u>

The physical nature of shelf waters is variable, being influenced in large part by fresh water land drainage and waters from neighboring shelf areas and the open Gulf. Due to the large volume of run-off from the Mississippi and Atchafalaya River systems, salinities in Louisiana shelf waters are generally lower than the average 35 parts per thousand found in oceanic waters. Surface water temperatures range from 65° F. in winter to 84° F. in summer (Leipper, 1954). Bottom water temperatures generally decrease with increasing depth; Corcoran (1973) found the lowest bottom temperature on the shelf to be 17° C. at 100 meters depth. Turbidity and light penetration are two related parameters that influence the composition and distribution of biotic groups. Turbidity is higher in nearshore areas, generally decreasing with distance from shore, but modified by current patterns. Light penetration, an important variable in organic production by photosynthesis, is inversely related to turbidity. The amount of turbidity is dependent on sediment discharge from rivers, sediment size, amount of particulate organic material in the water, and the amount of sediment resuspended by nearshore waves, currents, and storm surges. Nutrient levels, both organic and inorganic, are generally high in neritic waters, since these waters are more highly productive than

oceanic waters. After organic matter is broken down, the end products are again nutrients and are more readily available in shallow waters due to vertical currents and mixing.

(1) Primary Producers

The primary producers are those organisms capable of manufacturing their own food. The bulk of this production of food is accomplished by photosynthetic organisms using light as an energy source, although certain bacteria derive their energy from chemical bonds by a process known as chemosynthesis.

Primary producers in neritic waters are dominated by dinoflagellates and diatoms, with only a minor portion of organic production being contributed by seaweeds, bluegreen algae, and rooted grasses. Collectively, the unicellular and multicellular microscopic producers are called the phytoplankton. Their ubiquitous distribution and occurrence in pelagic waters is influenced by several factors. Steidinger (1973) stated that both horizontal and vertical distribution of phytoplankton are dependent on: 1) population origin and life cycles, 2) supply and level of nutrients and growth factors, 3) physiological requirements and adaptability, 4) salinity and temperature, and 5) grazing pressure by herbivores. In addition, vertical distribution alone is influenced by: 1) vertical mixing, diffusion, and water stability, and 2) depth of the lighted zone.

(2) Secondary Producers - Consumers

Secondary producers are incapable of manufacturing food from light, water, and inorganic carbon sources. They utilize the organic compounds and chemical bond energies in their food to produce compounds necessary for their subsistence. They are separated into trophic or feeding levels according to what they consume. Consumers which feed on plant material (phytoplankton, algae, etc.) are termed herbivores, or primary consumers. Animals feeding on herbivores are secondary consumers and the first carnivores. This system extends itself to form a hierarchy based on primary food sources. "Primary" is important here, in that rarely is a given organism restricted to one trophic level. Many food sources are utilized on an accidental basis; if acceptable food is encountered, it will normally be consumed. Food selection does occur, but diets of most consumers are usually varied, especially in times of stress such as low food availability.

Consumers are grouped on the basis of motility. The zooplankton are small organisms which, while they have some powers of independent movement, cannot perform effective horizontal migrations and thus float and drift according to tides and currents. The nekton, on the other hand, are those animals which, by virtue of their larger size, are able to overcome physical forces in large part. Organisms, such as certain bacteria, which decompose organic material, are found at all trophic levels of secondary production. It is difficult to establish how much decomposition occurs in the water column; however,

most authors agree that the bulk of decomposition occurs on, and in, the sea bottom (Odum, 1971).

(a) Zooplankton

Zooplankton distributions and occurrences are also relatively continuous in pelagic waters. In general, they are influenced by the same factors that affect phytoplankton distribution and occurrence. Inorganic nutrients and depth of the lighted zone are not as immediately important to zooplankton as to phytoplankton, but affect distribution and abundance in that greater availability of nutrients and light allow higher primary productivity and consequently a greater food supply for zooplankton.

The zooplankton is composed of representatives from many diverse biotic groups. Some of the more common and important members include the copepods, euphausiids, mysids, chaetognaths, pteropod and heteropod molluscs, and the salps and pyrosomes. Protozoans such as foramiferans and radiolarians may be locally abundant. Larval and juvenile forms of fish, crustaceans, and echinoderms are commonly found, usually being more abundant as the water depth gets shallower. Pelagic larvae and juveniles of organisms which inhabit the bottom as adults are called meroplankton, i.e., they only spend a portion of their life cycle in the water column. Those organisms which spend their entire life in pelagic waters are called holoplankton.

(b) Nekton - The Swimmers

Nektonic organisms are characterized by their ability to move about at will, being subject only to large-scale physical forces. Individuals of this group commonly, but not always, range over broad areas, thus participating in several biotic communities. For example, a semi-catadromous fish like the menhaden has a pelagic planktonic larvae, an estuarine juvenile, and a pelagic adult. However, most nekton are limited in geographic and vertical ranges by the same environmental conditions as less mobile organisms, i.e., temperature, salinity, available food, and types of bottom.

The nektonic component of the environment can be divided into strictly open water nekton, and nekton which spend some portion of their lives in nearshore, estuarine, or marsh waters. Many of the finfish of commercial and sportfishing importance are strictly open water residents, such as the red snapper, ling, various groupers, sailfish, and marlin. Alternatively, there is a large group of organisms, many of commercial importance, which spend part of their life inshore, usually as larvae and/or juveniles. This group includes anadromous species (those which live in salt water as adults and spawn in fresh water) such as shad, and the catadromous species (those which live in fresh water as adults and spawn in salt water) such as the common eel. Of particular importance from commercial and sportfishing standpoints are the semi-catadromous species such as the menhaden which spawn in open water, spend their juvenile stage in inshore waters, and return

to deeper waters as adults. Other members in this group include the white and brown shrimp, black drum and redfish, southern flounder and sand seatrout. Mullet and pompano commonly inhabit nearshore areas throughout their lives; however, adult pompano may be found at considerable distances offshore, although it is not known definitely if they spawn there.

Many of the organisms mentioned above, and many others not mentioned, are demersal; that is, they have a particular habit of living on, or just above the sea bottom. Since distribution and abundance of demersal organisms is generally regulated by sediment type and the bottom communities that supply food, these organisms will be more fully discussed in sections on the benthos and benthic communities.

b. <u>The Benthic Province - Sea Bottom</u>

The benthic environment is in general affected and defined by the same factors that influence the waters above the bottom. Additional factors to consider for the sea bottom alone are: 1) nature of the substrate, 2) nature of the sediment, and 3) sub-bottom temperatures, salinity, oxygen and pH. The substrate may be hard or soft depending on the amount and nature of sedimentation, and the degree of scouring by horizontal currents. Sediment type is usually described by percentages of carbonates, evaporites, sand, silt, and clay. Sub-bottom temperature, salinity, oxygen, and pH can be much different than overlying waters, especially the oxygen and pH values.

The benthic environment becomes more stable at greater depths, i.e., it is less affected by physical forces such as currents, waves, and storm surges. Temperature and salinity data tend to fluctuate less and have smaller ranges of values than in shallow water areas closer to the air-sea interface.

The plants and animals which constitute the living component of the benthic environment are collectively termed the benthos. Odum (1971) states that the benthos "...is characterized by the large numbers of sessile or relatively inactive animals which exhibit marked zonation in the inshore region." The organisms are generally distinct for each of the three neritic zones (supratidal, intertidal, and subtidal), but specific species may be found in more than one zone. Zonation is characterized more by dominant species than by distinct assemblages of numerous species.

(1) Primary Producers

The contribution to primary production in the ocean made by benthic plants is presumed to be small, although in certain nearshore localities, seagrass primary production may exceed the total of benthic algae and phytoplankton (Humm, 1973). Production by photosynthesis is limited to the depth of effective light penetration. Turbid nearshore waters reduce production, and, while offshore waters get clearer with distance from shore, the bottom is also increasingly deeper, and the normal extinction of light by water prevails. At a certain low level of ambient light, a given plant will use more energy in respiration than it can produce by photosynthesis. At this

light level and below, there is no longer any net primary production, and no excess organic matter that would be available to other organisms.

The main benthic producers are the seagrasses and the benthic algae. The seagrasses have been discussed previously, and their outer limits define the inner limit of the offshore environment for this report. The benthic algae predominantly inhabit rocky coastlines and hard bottoms. The scarcity of such habitats in the eastern Gulf means that the seagrasses dominate the benthic algae in this area (Humm, 1973). Representatives of the four major phyla of algae (Cyanophyta, blue-green; Rhodophyta, red; Phaeophyta, brown; Chlorophyta, green) may be found in suitable locations, but in offshore waters, red and brown algae predominate (Odum, 1971). In exceptionally clear waters, benthic algae are known to grow in at least 600 feet of water, especially coralline red algae, but apparently green, brown, and non-coralline red algae as well (Humm, 1973). Locally, in depths of 60-300 feet, there may be extensive bottom covers of algal nodules, fist-sized spheroidal aggregations of coralline algae and carbonate debris (Logan, 1969).

Endozoic [1/] algae make only a minute contribution to total primary production, but may be immensely important to the animal (or plant) they inhabit. Marine endozoic algae are predominantly the zooxanthellae, yellow-brown unicellular algae with dinoflagellate affinities. They inhabit a wide range of marine organisms, from sponges and corals to

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1/ Endozoic = Feeding within; refers to organisms that live within the tissues of other organisms, and derive their nutrition there.

many worms and molluscs (Droop, 1963). They form an intimate association with the animal host, which, while not necessarily an obligatory symbiosis, may be critical to host survival, especially in times of stress (Goreau, 1963; Yonge, 1935, 1944, 1958).

(2) <u>Secondary Producers - Consumers</u>

The benthic environment contains a wide variety of consumers, including representatives from almost all animal phyla. They range from the sessile organisms like sponges and anemones to slower moving forms such as shrimp and lobsters to the highly motile demersal fish. Demersal fish are those which live on or near the bottom and depend on the bottom for their food supply. These include the flounders (inshore) and the red snapper and various other bottom fish that prefer banks (offshore). Numerous topographic rises on the Texas-Louisiana OCS, many underlain by salt dome formations (see Section II.A.) provide habitats for snapper and/or grouper populations. In addition to the rises, other irregular bottom conditions such as ledges and stillstands serve as habitats for these fish. Although we have no positive evidence as to whether all these rises are actual (either permanent or temporary) snapper and/or grouper banks, there are numerous reports of successful hook-and-line fishing on these banks. We have elected to consider all significant topographic rises on or near proposed lease tracts as <u>potential</u> snapper/grouper fishing areas, and have treated them as such in this section, in the impact of commercial fisheries, and in the matrix analysis of the lease tracts involved.

Perhaps the most important consumers from a human economic standpoint are the shrimp. Louisiana waters are the center for white shrimp (Penaeus setiferus) catch, with approximately equal inshore and offshore catches. In the last 20 years, the offshore brown shrimp (Penaeus aztecus) catch has steadily increased off Louisiana. Of less importance are the shallow offshore species of pink shrimp (Penaeus duorarum) and sea bob (Xiphopenaeus kroyeri). An even smaller quantity of royal red shrimp (Hymenopenaeus robutus) is found in the deeper waters from 175 to 300 fathoms.

Non-commercial organisms are also important components of the benthic environment. Conspicuous members of certain phyla such as echinoderms, molluscs, decapod crustaceans, and larger annelid worms are better studied than the smaller organisms such as nematodes and foraminiferans. Many of the conspicuous organisms are epifaunal, living at the sediment-water interface. Dense aggregations of brittle stars and crinoids are frequently encountered. Infaunal organisms, living in the sediment, must not be slighted, however, as they play a major role in reworking the sediment. These include the burrowing forms of echinoderms and molluscs, various nematodes, flatworms, and annelids, and the marine bacteria. Bacteria are important chemical and geological agents in marine bottom deposits where they promote chemical transformations involving organic compounds, inorganic constituents, and physico-chemical conditions that affect the modification of diagenesis of sediments (Zobell, 1954).

c. The Aerial Province - Sea Birds

Birds are an important component of the marine environment, although their relationship to the water is unlike any other class of animals. The birds of offshore waters can be grouped into those which only visit land to breed, and those which nest and live on shore, and only go offshore to feed. Regardless of grouping, the birds participate in nutrient energy cycling by their carnivorous feeding habits, their nitrogenous wastes, and their corpses. Nearly 400 species of birds have been recorded in or flying over the eastern Gulf of Mexico, 81 of which are importantly affected by the existence and conditions of saline habitats (Woolfenden and Schreiber, 1973).

The first group, the true pelagic birds, have not been well studied, due to the difficulty of observing them at sea. There are only a few species, and apparently most of these only occur in small numbers (Woolfenden and Schreiber, 1973). Lowery and Newman (1954) mention 24 species of pelagic birds known from the entire Gulf. Those authors state that only 12 species can safely be presumed to occur regularly every year. Several of these are only found as far north as the southern Gulf. Over offshore Louisiana waters, one can expect to find: (year-round), brown and blue-faced boobies; (in summer), Wilson's petrel, magnificent frigate (or man-o'-war) birds, pomarine and parasitic jaegers; and (in winter) the gannet and Bonaparte's gull. Rare birds include the resident Audubon shearwater, the

winter visitors including the red phalarope, white-winged, surf, and common scoters, and sooty terns in summer.

The shore dwelling birds that fish offshore commonly inhabit beaches, sandflats, and dunes in Louisiana, and are dominated by the gulls and terns (U.S. Army Corps of Engineers, 1973). Year-round residents include Forster's tern, the royal tern, and the black skimmer. The threatened eastern brown pelican (Pelecanus occidentalis carolinensis) is also a resident, but maintains only one breeding ground in Louisiana on Grand Terre Islands at the south end of Barataria Bay (U.S. Army Corps of Engineers, 1973). Winter visitors include the ring-billed and herring gulls, the common tern, and the white pelican. During summer, the least tern is common, and the black tern and sandwich tern occasional.

2. Communities and Food Webs

Odum (1971) defines a biotic community as "..any assemblage of populations living in a prescribed area or physical habitat; it is an organized unit to the extent that it has characteristics additional to its individual and population components and functions as a unit through coupled metabolic transformation." Marine biotic communities are difficult to describe, however, due to the lack of physical demarcations of habitats and the variability of conditions within certain ranges. Various authors have approached the description either through trophic levels or broad physical zones (neritic, benthic, etc.).

Allee (1949) took an extreme view in the following statement: "The major marine community despite its great regional biotic variation, is so lacking in effective barriers to dispersal, is so much subject to slow continuous circulation of its medium and exhibits so much interdependence of its components from region to region and area to area, that it may be regarded as a single biome type." While this view has merit, an attempt will be made to delineate communities based on broad habitat and feeding interrelationships.

a. Neritic Province

Communities of the neritic province are the most difficult marine communities to delineate, due to the absence of physical barriers to population dispersal. This study area is more conveniently described in terms of the organisms which at various times and places are found together in assemblages. These assemblages are determined by water characteristics (temperature, salinity, nutrient availability, etc.) and biotic factors (grazing, competition, predation, physiological tolerances, etc.). The distribution and occurrence of these assemblages geographically is transitory; vertical distribution of assemblages in the water column is somewhat more stable.

The lighted zone of the water column contains an assemblage which at times may have representatives of a complete food web, from primary producers to top carnivores and may include decomposing organisms. The microscopic primary producers of the euphotic (lighted) zone are

dominated by diatoms and dinoflagellates. Diatoms are generally more abundant than dinoflagellates, and comprise the bulk of the biomass (Simmons and Thomas, 1962; Curl, 1959). Dinoflagellates may be locally dominant, as during red tides where they are the causative agents, or in silicate poor waters which make capsule formation difficult for diatoms (Steidinger, 1973). Conger, et. al. (1972) lists 908 species, varieties, or forms of diatoms in 110 genera from the Gulf. Steidinger (1972) lists 404 species of dinoflagellates in 61 genera from the Gulf and adjacent coastal areas.

Several authors have discussed the phytoplankton assemblages near the study area at hand. Curl (1959) documented the phytoplankton found in Alligator Harbor, Florida and the northeastern Gulf. He noted that the diatoms were most abundant in numbers and species, and the genera *Rhizosolenia* and *Chaetoceros* comprised between 8 and 65% of the individuals in any tow in 1954. They were responsible for most of the phytoplankton biomass in that year. The characteristic dinoflagellate was *Podolampas elegans* Schütt.

Simmons and Thomas (1962) sampled phytoplankton from the eastern Mississippi delta and described two assemblages associated with different salinity regimes. A low salinity regime of river water had an assemblage dominated by two species each of the genera *Cyclotella*, *Melosira*, and *Navicula*. A higher salinity regime of Gulf waters had an assemblage composed of *Nitzschia seriata*,

Thalassiothrix frauenfeldii, *Thalassionema nitzochioides*, *Skeletonema costatum*, *Asterionella japonica* and three species of *Chaetoceros*. This Gulf water regime near the fresh water plume has higher diversity due to mixing of fresh water and marine genera. Seasonality of species (presence and abundance) was also noted, being more variable in the Gulf regime than in the river regime. In both areas, the lowest diatom abundances (standing crop) were noted in November. Dinoflagellates were minor constituents of the phytoplankton observed by Simmons and Thomas near the delta. Widespread, but nowhere abundant, genera include *Ceratium*, *Glenodinium*, *Goniodoma*, *Pyrocistis*, *Hypodinium*, *Gymnodinium*, *Gloedinium*, *Peridinium*, *Hemidinium*, and *Dinophysis*.

Stowe (1972) studied the diatoms near Barataria Bay, Louisiana, finding *Cocconeis*, *Amphora*, and *Denticula* to be the most abundant genera. Epiphytic diatoms showed a continual rise in abundance from January to September, with a generalized bloom occurring from October to November.

Sanders and Fryxell (1972) plotted the distributions in the Gulf of 14 diatom species. The 14 species were selected on the bases of: 1) frequency of occurrence, 2) ease of identification, 3) sufficient size to be retained in net collections, and 4) interesting relationships to environmental influences. The group included two species each of the genera *Chaetoceros*, *Hemiaulus*, *Biddulphia*, *Hemidiscus* and *Rhizosolonia*, and one species each of *Guinardia*, *Thalassionema*, *Certaulina* and *Asterionella*. All were observed in neritic waters off Louisiana west of the delta, with *Chaetoceros coarctatum*, *C. compressum*, *Cerataulina*

pelagica, *Hemiaulus membranaceus*, *Guinardia flaccida*, and *Rhizosolonia alata* the most commonly encountered species. *Rhizosolonia alata* was the most frequently observed species over the entire Gulf, and is found during all months of the year. *Guinardia flaccida* is also found in all months, and in most months *Chaetoceros compressum*, *C. peruvianum*, *Hemiaulus membranaceus* and *Rhizoselonia stolterfothii* can be found (Balech, 1967).

Dinoflagellate distribution was reviewed by Steidinger (1972), who mapped occurrences of 14 frequently found species in the Gulf. Commonly occurring species in Louisiana offshore waters were: *Ceratium furca*, *C. fusus*, *C. trichoceros*, *Peridinium brochii*, and *Ceratocorys horrida*. *Ceratium*, with 80 species, and *Peridinium*, with 76 species, are the most diverse genera in the Gulf, and usually the most abundant. Species diversity of dinoflagellates was found to be higher offshore (where it occasionally exceeds diatom diversity) than nearshore, while dinoflagellate abundance was higher nearshore than offshore. From Florida Department of Natural Resources data, Steidinger estimates estuarine and inshore abundance as 1-2 x 10^4 cells/liter (except 1-5 x 10^5 cells/liter in enriched areas), offshore neritic at 1 x 10^4 cells/liter, and oceanic values at "hundred of cells per liter".

Steidinger (1973) surveyed the phytoplankton of the eastern Gulf and outlined four broad types of assemblages: 1) estuarine, 2) estuarine and coastal, 3) coastal and open Gulf, and 4) open Gulf. The coastal/

open Gulf assemblage would include the diatoms *Hemiaulus hauckii* *Chaetoceros compressum*, *Thallassiothrix frauenfeldii*, *Plagiogramma vanheukii*, *Guinardia flaccida*, *Rhizosolonia robusta*, *R. imbricata*, the blue-green alga *Oscillatoria* (= *Trichodesmium*) *erythraea*, and the dinoflagellates *Ceratium furca*, *C. fusus*, *C. trichoceros*, *C. massiliense*, *C. carriense*, *C. tripos*, *Blepharocysta splendormaris*, *Heteraulacus polyedricus*, *Peridinium* spp., *Podolampas* spp., and *Diplopsalis lenticula* var. *asymmetrica*.

The open Gulf phytoplankton assemblage would include the diatom genera *Gossleriella*, *Ethmodiscus*, and *Planktoniella*, and the dinoflagellate genera *Triposolenia*, *Heterodinium*, *Amphisolenia*, *Murrayella*, *Histioneis*, *Ptychodiscus*, *Cladopyxis*, *Kofoidinium*, certain *Ceratium* spp. and *Pyrocystis*, according to Steidinger. While the dinoflagellates are more diverse in this area, they do not necessarily dominate the standing crop.

The assemblages described by Steidinger are not meant to imply strict groupings. Many species are found in more than one area, being subject to current and wind patterns. *Rhizosolonia alata* has been found in all four areas. The four groupings show certain associations, however, such as the greater dinoflagellate diversity in open Gulf waters.

Vertical stratification of phytoplankton is well established, but quantitative information on vertical distribution of species is sparse, due to collecting problems (passage of microplankton through net, determination of true depth fished). This aspect of distribution is

generally subsumed under studies on primary production and standing crop, which are commonly measured by C^{14} and chlorophyll-a techniques. El-Sayed (1972) plotted the surface distribution of chlorophyll-a based on numerous measurements, and found high values in neritic waters off Yucatan, northwest Florida, and the Texas-Louisiana coasts. Nearshore values were nearly twice as high as offshore. Vertical distribution of chlorophyll-a was notable for low surface values and the maximum concentrations at some distance below the surface, commonly between 50 and 100m. In many cases, the maximum chlorophyll-a concentration was found at and sometimes below the bottom of the euphotic zones (1% of surface light level).

Primary production, as measured by C^{14} methodology by El-Sayed, resembles phytoplankton standing crop in geographical distribution. In the water column, maximum carbon assimilation occurred at depths corresponding to 50%-25% of surface light intensity, and decreased gradually to the bottom of the euphotic zone.

Steidinger (1973) suggests that spring and summer are the seasonal peaks for standing crop and primary production in estuaries and coastal areas. On the other hand, winter may be a peak period in offshore and open Gulf waters (El-Sayed, 1972). El-Sayed showed chlorophyll-a to be high in winter, lowest in spring, with a general increase in summer and fall. The amplitude of the seasonal variation is not great, however. Primary production follows the same trend, i.e., winter maximum and damped variation of amplitude.

Phytoplankton assemblages are merely a part of larger biologic assemblages in neritic waters. These larger assemblages also contain zooplankton and nekton representatives, and present a complicated web of interrelationships. These relationships are difficult to assess, with much of the effort to date being devoted to determining broad feeding relationships and assignment to trophic levels.

The zooplankton offshore have not been as well studied as the phytoplankton, but some generalizations have been made. The most important grazers (herbivores) are the copepod crustaceans, which are also the most abundant zooplanktonic group, which are found in any given plankton sample (Raymont, 1963). The distribution of copepods is dependent on factors mentioned previously in the neritic province-shelf waters. The herbivorous feeding habit superimposes a localized abundance (patchiness) on the general distribution pattern. Where phytoplankton populations become abundant, copepod populations will also flourish after a lag period of growth of young and immature stages, and their eventual second generation spawning.

Common copepod species found in neritic Gulf waters include the calanoid copepods Euchaeta marina, Neocalanus gracilis, Scolecithrix dana, Candacea pachydactyla, Unidinula vulgaris, Eucalanus attenuata, and Acartia tonsa, as well as the cyclopoid copepods Copilia mirabilis and Corycaeus spp. Euchaeta and Corycaeus differ from the rest in being carnivorous. Acartia tonsa is a dominant nearshore form in bays and estuaries, and is found less commonly offshore. Gillespie (1971)

found Acartia tonsa in nearly every sample (681) taken in coastal Louisiana, and the copepod accounted for an average of 60% of each sample.

Euphausiid crustaceans are prominent members of the zooplankton assemblage. Major species found in the Gulf are Euphausia americana, E. mutica, E. brevis and Stylocheiron carinatum. Feeding habits of euphausiids have variously been described as herbivorous, carnivorous and detritivorous.1/ While some, e.g. Euphausia superba in the Antarctic, appear to be strictly herbivorous (Raymont, 1963), it seems best to conclude that euphausiid species are at different trophic levels or each species has a range of organic material from which to satisfy nutritional requirements.

Possibly the most significant carnivores in the zooplankton are the chaetognaths, or arrow worms. Copepods dominate the diet but this may be an artifact based on relatively high copepod abundance (Raymont, 1963). They also feed on fish and barnacle larvae. The genus Sagitta is common worldwide; Gulf species include S. setosa, Pterosagitta sp., Krohnitta sp., and Eukrohnia sp.

Other common carnivores in the zooplankton include the ctenophores (Pleurobrachia and Beroe), medusae of various species, ostracods, cladocerans (Podon and Evadne), mysid and amphipod crustaceans, heteropods (Atlanta leseuri), pteropods, salps and pyrosomes. Another significant group of carnivores are the various larval and immature forms, both holoplanktonic and meroplanktonic, from several phyla. These include

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1/ Detritus feeders.

most of the crustaceans mentioned, the tunicates, echinoderms, cephalopods, ectoprocts, sponges, annelid and nemertine worms. Fish larvae are important carnivores, and the survival of larvae of commercial fish has obvious economic import.

It must be noted that the relations of the various carnivores and herbivores with their food and as food produces a complicated network of mutual influences. Rarely is a carnivore restricted to a single trophic level, but rather derives its food from several trophic levels. Omnivory (utilizing plants and animals as food) is known to occur, especially among the euphausiid crustaceans and many filter feeders. The numerous interrelationships are only recently being elucidated, and progress is slowly being made to fill in the gaps.

Members of the nektonic assemblage, since they are mobile enough to overcome all but the large-scale physical forces, range over broad area of the pelagic environment. The group includes squid and the schooling fishes, such as the amberjack, crevalle jack, horseeye jack, bluefish, king mackerel, various anchovies and herrings, and menhaden. The anchovies, herrings, and menhaden are mainly planktivorous 1/ herbivores, feeding mainly on diatoms and dinoflagellates and rarely on zooplanktonic crustaceans (Rounsefell, 1954). Menhaden are of particular importance in that the menhaden fishery is the largest single fishery in the U.S. today, and most of the menhaden catch now comes from the Gulf of Mexico, primarily from the waters around the Mississippi delta (U.S. Army Corps of Engineers, 1973).

1/ Feeding on plankton size organisms.

Several types of pelagic fishes do not travel in schools, but rather roam alone or in small groups. These types include the cartilaginous fish, the sharks, mainly bull, sharpnose, blacktip, mako, hammerhead and great white sharks, and the bony fish, such as atlantic sailfish, blue marlin, dorado (dolphin fish), and cabio (ling or cobia). Most of these solitary or small school fishes are carnivorous, feeding on smaller fish, squid, chaetognaths, and other macroplankton. Their diets are generally unrestricted; while some preferences may be shown, they are generally adventitious feeders, that is, they feed on whatever animal material is available.

Benthic communities are somewhat easier to define than pelagic communities, due to the fact that the bottom represents a barrier to many organisms, a surface of action (feeding, reproduction) for others, and a haven of protection for the burrowing forms. Communities still range over broad areas, however, due to extensive areas of similar environmental conditions. Collard and D'Asaro (1973), quoting several other authors, state that, while abiotic factors such as temperature, salinity, turbidity, sediment depositional rates, currents, physico-chemical and geographic barriers are important modifiers of community structure and distribution, substrate remains as the single key abiotic factor influencing communities. Biotic modifiers and determinants of community structure include predation, competition, physiological tolerances, and population characters (fecundity, longevity, mortality, etc.).

Benthic communities of offshore areas can be broadly described as shallow shelf communities, deep shelf communities, and slope communities. Within these broad areas, more specific communities can be described for shrimp grounds, sand bottoms, silt and mud bottoms, rocky bottoms, and hard banks.

Figs. 30-32 are modified Petersen diagrams compiled by Collard and D' Asaro (1973) to illustrate the shallow shelf, deep shelf, and slope assemblages. They are but three of eleven assemblages described by these authors, the others being inshore communities which are discussed elsewhere. The diagrams illustrate differences in assemblage composition between hard and soft bottoms, and these differences within each diagram are probably more significant than the differences between diagrams. The differences between diagrams are depth and latitudinal differences, and the faunal assemblages were described by the authors as indicating Carolinian province (shallow shelf) and West Indian province (deep shelf) affinities. Common names of animals listed in these figures is included as Attachment P.

The fauna of the brown shrimp fishing grounds in the western Gulf of Mexico was described by Hildebrand (1954). Shrimp grounds are always soft bottom areas, and shrimpers prefer level areas free of projecting features. Hildebrand's study was concentrated west of Sabine Pass but a few trawls were made on the Southwest Pass grounds. The 10 most

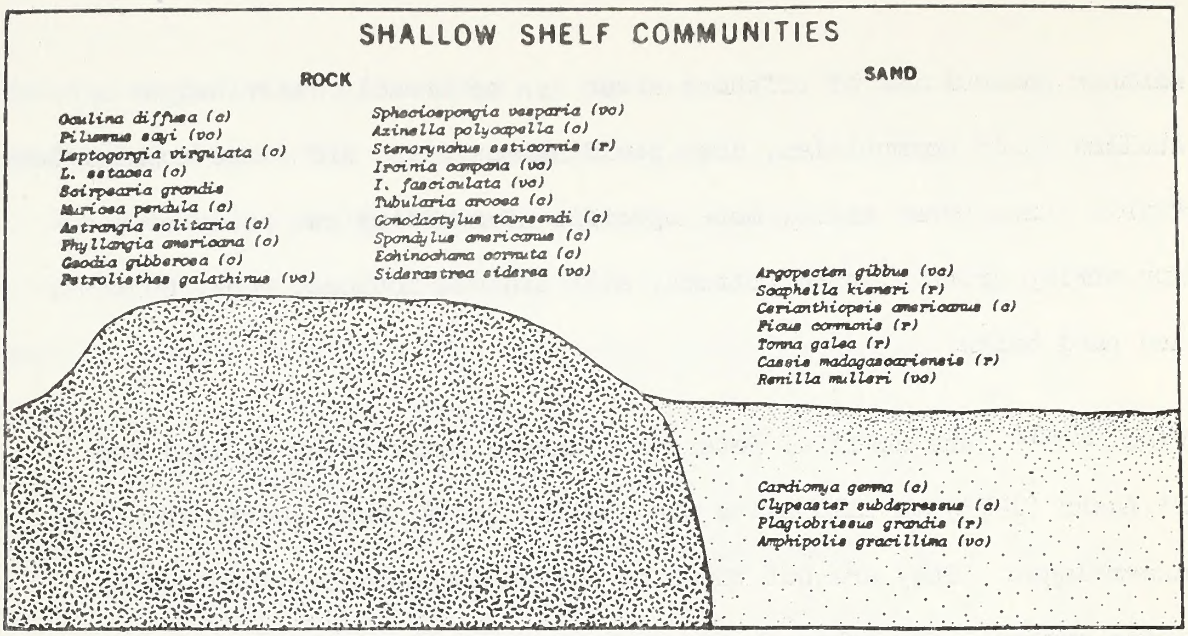

Figure 30. Shallow shelf communities: Carolinian affinities. These communities are continuous with the high energy beach and jetty communities and often contain the same species. (from Collard and D'Asaro, 1973)

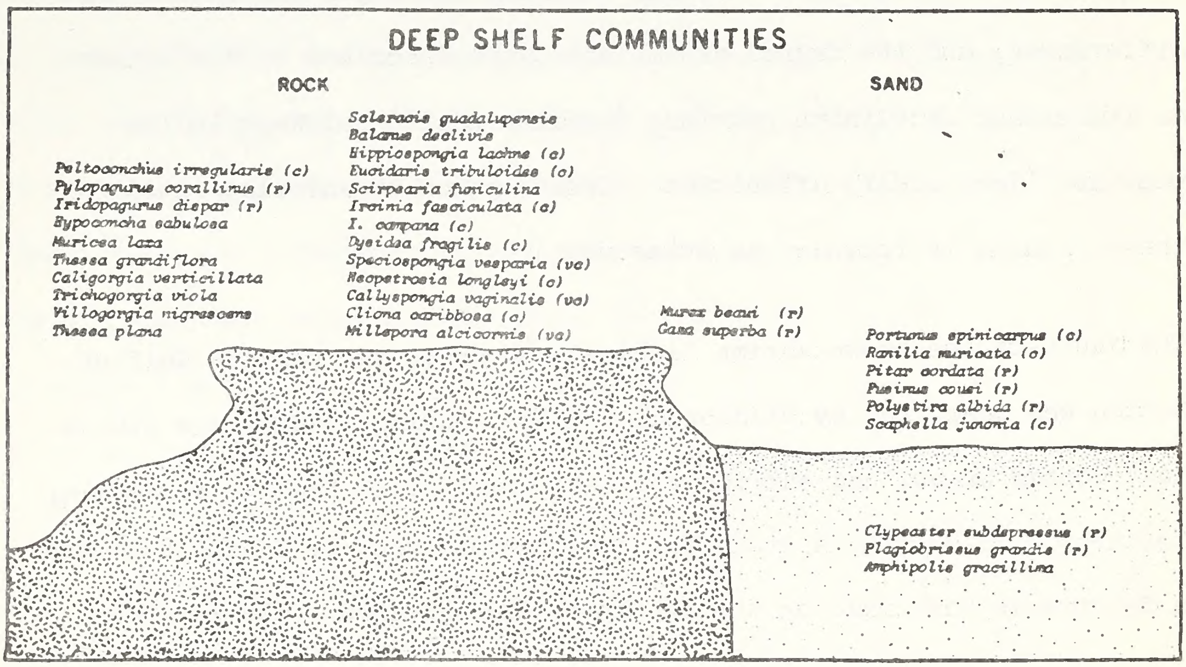

Figure 31. Deep shelf communities: West Indian affinities. Species occurring on the shelf exhibit strong West Indian affinities. (from Collard and D'Asaro, 1973)

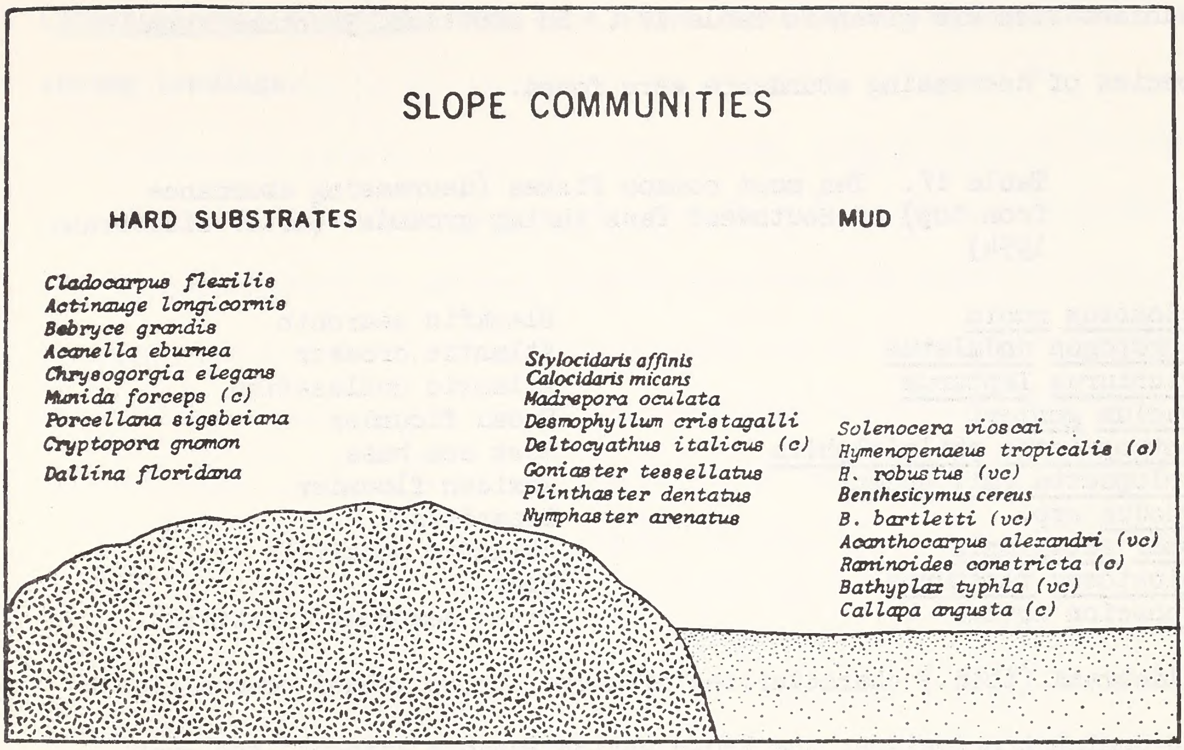

Figure 32. Slope communities. Many species found here are common throughout the Gulf of Mexico and are found in the Atlantic Ocean and the Caribbean Sea. (from Collard and D'Asaro, 1973)

abundant fish are given in Table 27 . In addition, 38 other fish species of decreasing abundance were found.

Table 27. Ten most common fishes (decreasing abundance from top) of Southwest Pass shrimp grounds. (after Hildebrand, 1954)

Prionotus rubio	Blackfin searobin
Micropogon undulatus	Atlantic croaker
Trichiurus lepturus	Atlantic cutlassfish
Syacium gunteri	Shoal flounder
Centropristis philadelphica	Rock sea bass
Cyclopsetta chittendeni	Mexican flounder
Synodus spp.	Lizardfish
Vomer setapinnis	Atlantic moonfish
Leiostomus fanthurus	Spot
Cynoscion nothus	Siver seatrout (weakfish)

Hildebrand (ibid.) characterizes offshore shrimp ground communities by the dominant organisms; the brown shrimp Penaeus aztecus, the crab Callinectes danae, the pelecypod Pitar cordata, the conch Busycon contrarium, the starfish Astropecten antillensis, shoal flounders and butterfish. Inshore grounds are dominated by the white shrimp Penaeus setiferus, Callinectes danae, the sea pansy Renilla mulleri, the pelecypod Pitar texasiana, silver seatrout, Atlantic croaker, Atlantic threadfin, and sea catfish. The Southwest Pass grounds specifically are characterized by brown shrimp, blackfin searobin, Atlantic croaker, Atlantic cutlassfish, shoal flounder, and the stomatopod crustacean Squilla empusa.

Shrimp populations are found in many areas offshore Louisiana. The shrimp fishery has been a mature fishery since the 1920's; brown and white shrimp have been the two most significant species, with brown shrimp accounting for most of the harvest in recent years (Stone, 1972). Pink shrimp (Penaeus duorarum), sea bobs (Xiphopenaeus kroyeri) and royal red shrimp

(Hymenopenaeus robustus) make up a minor fraction of the Louisiana shrimp landings.

F. Description of Commercially Important Fisheries

Of the major fisheries of Louisiana, all of which are significant as members of a larger food chain or food web, some take on added significance because of the large amount of biomass produced for eventual human consumption. Several species of fishes landed in Louisiana waters and in the adjacent Gulf of Mexico waters are caught in quantities excessive of 100,000 pounds per year. Based on statistics published by the National Marine Fisheries Service, 1973, these species, as listed in decending order of quantities, are:

1. Menhaden
2. Catfishes and Bullheads
3. Buffalofish
4. Seatrout, Spotted
5. Drum, Red
6. Shad
7. Sheepshead, freshwater
8. Drum, Black
9. Garfish
10. Flounders
11. King Whiting
12. Croaker
13. Snapper, Red
14. Sheepshead, saltwater
15. Spanish Mackerel
16. Carp

Important shellfish include:

- Blue crabs
- Crawfish
- Shrimp
- Oysters

Shellfish are discussed in Section II.D.8., Estuaries and Embayments.

For data on pounds of fish caught see Section II.G.3 of this statement.

The various phases of the life history patterns of these fishes take place in the offshore waters of the Gulf of Mexico, in the bays, estuaries and marshes of the coastal zone, in the fresher waters of the Mississippi River, and in freshwater marshes and bayous. Some fishes spend their entire life cycle in one of these habitats, but most of them move from one to the other from the time of spawning to adulthood.

Red drum or red fish, sea trout and croakers were once grouped as a single family. They are now considered as belonging to the drums and croaker (Sciaenidae) and the weakfishes (Otolithidae). For the sake of clarity, an ennumeration of the members of these groups which are discussed in this section follows:

<u>Croakers and drums</u>

Red drum, redfish or channel bass
Croaker
Kingfish or whiting
Black drum, drum, or sea drum

<u>Weakfishes</u>

Spotted sea trout
White sea trout

Gresham (1965) has described the life histories of the fishes. The following discussion is based largely on his work with other references included as appropriate.

The red drum, <u>Sciaenops</u> <u>ocellata</u>, or redfish is one of Louisiana's most important fishes. This species spawns mainly in October and, in the Gulf of Mexico, at the mouths of the various passes. When

hatched, the larval appear to be carried by tidal currents into bays and lagoons where they remain for an indefinite time. Growth studies indicate that by the end of the first year, a red drum reaches an average length of 13½"; by the end of the second year - 29½"; and by the end of the third year - 32". This species breeds after the third or fourth years.

Pearson (1928-29) suggested that after these fish enter the bays and lagoons from spawning areas in the Gulf of Mexico, the larval and young (juvenile) red drum tend to scatter and seek, during their earlier life, the shelter of grassy, quiet coves. They avoid bare or sandy bottoms. They would thus be expected to frequent the submerged grasslands on the landward side of the barrier islands (Section II.D.5 and 7) and the saltmarshes of eastern Louisiana (Section II.D.1).

According to Gresham (1965), after the red drum enter the shelter of grassy areas, they remain there until fall and, with the coming of winter weather, the young red drum move into the deeper bays from the shallow coves and tidal flats. The following spring, they wander into the Gulf of Mexico and, within a year, may have travelled as much as 75 miles from their original spawning grounds. Red drum travel in schools, live in the deeper waters of the Gulf of Mexico during winter, and return to the shallower bays and estuaries during the summer.

The diet of red drum is chiefly composed of crustaceans such as shrimp and crabs. Penaeid shrimp are favored, while the blue crabs are consumed as a second choice. Red drum frequently eat silversides, mullet or gobies. In one case, the stomach of a 27 inch red drum contained an 8 inch mullet (Gresham, 1965).

The black drum or sea drum, *Pogonias cromis*, chiefly spawn from February to May in the passes leading from the Gulf into the bays, bayons and lagoons. Pearson's (1928-29) studies found evidence of a late spawning in the latter part of July to the early part of November. He did not believe the spawning of black drum occurred in shallow waters of bays and estuaries.

The young black drum are extremely presistent in remaining in the shallow inter-coastal waters of Texas and Louisiana, both in summer and in winter, although spawning does not occur there.

Again according to Gresham (1965), black drum are largely bottom feeders, and feed on small shellfish or clams, *Mulivaris transversa carbuloides*. Pearson's observations, as cited by Gresham, indicate that the black drum also consume mussels, *Mytilus sp.*, and oysters, *Ostrea sp.*, small crabs and shrimp. The black drum suck up shellfish buried in the mud and crush the shells with their pharyngeal teeth. A single large drum contained as much as two pounds of broken shell.

The croaker or Atlantic croaker, Micropogon undulatus, is closely related to the drum fishes in life history pattern and food preferences. The account of Parker (1971) provides the basic information about this species. The Atlantic croaker spawns as an adult in offshore Louisiana near the passes and channel entrances to estuaries and lagoons. Welsh and Breder (1923) stated that spawning took place in the estuaries. Numerous authors, including Suttkus (1955), have described the spawning season as extending from September through March, and Suttkus concluded that the bulk of spawning occurred from October through January. Upon hatching, the young move into the bays and lagoons which they utilize as nursery grounds. Post larval of croaker 1/ have been reported in the waters of Louisiana (El-Sayed, 1961) with the peak influx occurring during November or December. Young of the year return to the sea with the onset of cold weather (Wallace, 1940; Suttkus, 1955, among others) and Wallace found that one year old fish return to the inshore waters in the spring where they remain until they approach maturity in late summer. Pearson (1929) and Gunter (1945) concluded that croaker spawn at the end of their second year, whereas Wallace (1940) found that males mature at two years of age and females during their third year.

Gulf kingfish or whiting, Menticirrhus littoralis is an offshore species of the croaker family and is rarely taken at salinities below

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1/ Post larval of croakers - a fish with a total length of less than 30 mm.

14. 4 ppt (Burleigh, 1964). The fish usually lives in salinities above 30 ppt where it spawns, grows and feeds until adulthood is reached. Kelly (1965) found that presence of Gulf kingfish in the Delta Refuge were restricted to passes that traverse the refuge.

Members of the weakfish family, the white seatrout, Cynoscion arenamis, and the spotted sea trout, Cynoscion nebulosis, are found in most bays and inshore areas on the Gulf coast (Heald, 1970). The white seatrout, however, is primarily an offshore species which spawns in winter through fall in the offshore Gulf of Mexico. The spotted sea trout, spawns in the grassy areas off of barrier islands and the saltmarsh while later migrating to channels and passes. The diet of these two fishes consists of crustaceans and small fishes (Kilma and Jabb, 1959). The spotted trout spawns almost entirely within the bays, lagoons and bayous in contrast to the red and black drum which usually spawn offshore (Gresham, 1965). The breeding season reaches a height in April and May, but spawning sometimes continues throughout the spring and summer. Stomach analysis of this sea trout show that the fish consumes croakers, spot, mullet, silversides, anchovies in addition to some small crustaceans.

Belonging to a different family of fishes (Sparidae) the sheepshead, Archosargus probatocephalus, is a small-mouthed fish provided with

powerful teeth which are used to crush crabs and shellfish, the primary food sources.

The sheepshead appear to spawn in March and the eggs float freely in the sea until they hatch within a period of forty hours in a temperature of 77° Farenheit. (Gresham, 1965). After offshore spawning, the sheepshead move into the bays and estuaries of the coast where they remain during the summer (Gowanlock, 1933).

Of the family Clupeidae, which includes the menhaden, shad and herring, the menhaden Brevoortia patronis is an extremely important commercial fish (used for the production of fish meal and oil).

Menhaden spawn offshore from October to March, where the pelagic eggs hatch in about two days. The larvae drift and swim into the estuaries, where they remain until they become juveniles. At this time the feeding habits change from discriminate particulate feeding larvae, (mainly zooplankton) to filter feeding juveniles. This filter feeding continues throughout the rest of the menhaden's life. The juveniles remain in the estuaries until the temperatures start to drop in the fall. At this time they migrate in schools into the open Gulf.

The menhaden matures in less than two years at which time it spawns and the cycle repeats itself. Each female can release several hundred thousand eggs during a spawning season (Day, 1973).

Two species of shad inhabit the Louisiana coast in large numbers. The gizzard shad, <u>Dorosoma cepedianum</u>, and the threadfin shad, <u>Dorosoma petenense</u>. Gizzard shad is one of the most abundant fishes in the ponds and passes within marshland areas. They are found in waters of salinity 6.9 o/oo to 17.4 o/oo (Burleigh, 1966). Gunter (1945) found that in Texas, the gizzard shad is more numerous in October and November in waters of salinity from 2.0 o/oo to 33.7 o/oo although they preferred a range of 0.0 to 15.0 o/oo.

Threadfin shad live in the open waters of estuarine and river passes in the summer and move into warmer ponds during the winter (Kelley 1963).

Although the grouper catch was not 100,000 lbs or more in one year, groupers are significant because they reside on or near topographic rises, ledges and irregular bottom topography. Since groupers are commonly found in these areas along with snappers, we will discuss these two groups of fishes together.

Snappers and groupers are similar in their choice of habitat and food -- both inhabit the reefs and banks and are carnivorous.

Spawning takes place in July and August for snappers of the genus <u>Lutjanus</u>. These fish grow slowly, reaching maturity at around 12 inches in length but continuing to grow to a total length of over 30 inches (Taylor, 1973).

Although snappers have been fished for over a century, little is known about their life history.

Groupers are found in warm waters in close proximity to reefs or banks. Members of the genera _Mycteroperca_ and _Epinephelus_ are found on the Gulf of Mexico banks. They are generally long-term residents of these banks, migrating only during spawning season to predetermined areas.

Their reproductive mechanisms are specialized, and usually exhibit different types of hermaphroditism 1/. The change from female to male is related to environmental conditions. Under poor conditions, the conversion rate to males will be higher, thus decreasing the number of offspring produced (Taylor and Bright, 1973).

Although these carnivorous fish eat all the time on small fishes and crustaceans, their most active feeding takes place at dawn and dusk (Taylor and Bright, 1973).

There is a great variation in growth rates of individuals in each age group. This is probably due to both environmental conditions and genetic variations (Taylor and Bright, 1973).

Taylor and Bright summarize the groupers as follows:

"a) Groupers maintain residence for extended periods on shallow reefs or banks during their first 4-6 years. They are considered sexually immature at this stage and are not involved in any migration to deeper water to spawn.

b) Sexually mature groupers migrate yearly to a predetermined area near their habitat for spawning aggregations.

1/ Hermaphroditism - An animal with the sexual organs of both the male and the female.

c) After their initial "stay of residence: on a shallow reef, some species may migrate into deeper water (at age 5-6 years) not necessarily to remain there. In addition, their range may be extended following their maturity as females.

d) Possible exceptions to these conclusions are the Epinephelus adscensionis, E. guttatus and E. cruentatus which probably are confined to a particular reef for their entire life span."

Scomberomorus spp., the mackerels, are schooling pelagic fish. Although the Spanish mackerel, S. maculatus, spawns a little later than the King mackerel, S. cavella, they both reach their peak of spawning activity during the summer in the northeastern Gulf.

Mackerels migrate to the south during the winter but return to the northern waters in the spring and fall. The food preference of these carnivorous fish is primarily fish from the family Clupeidae (herrings) but they eat other fish and invertebrates such as mullets, needlefish, and shrimp (Taylor, 1973).

Left-eye flounders are members of the Bothidal family and right-eye flounders are members of the family Pleuronectidae. They are characterized by their flat bodies and the position of their eyes -- both on one side of the body.

Spawned from September to April (Gunter, 1938), flounder larvae are symmetrical, and within a few days one of the eyes migrates to the opposite side of the head. When the young settle out of the plankton, they lie on the bottom with their blind side down.

These carnivorous fish dart out at their prey (small fishes and crustaceans) and then resume their place on the bottom. Flounders have the ability to alter their coloring to match the bottom. By partially burying themselves in the sediments, they add to their camouflage (Randall, 1968).

Flounders prefer mud bottom areas of bays, sounds, and lagoons (Louisiana Wildlife and Fisheries Commission, 1971).

Several fish species of considerable economic importance in Louisiana are primarily freshwater dwellers and are not greatly affected by the OCS oil and gas operations under consideration in this impact statement. These fishes include the catfishes, especially the channel or white catfish, *Ictalurus punctatus*, the blue cat, *Ictalurus furcatus*, and the bullhead or horned pout, *Amerirus nebulosis*. Although the blue cat has been captured in Mississippi Sound (Gresham, 1965) it, along with other catfishes, are found in the freshwater of the Mississippi basin on up to the Great Lakes.

Buffalofishes and carp are primarily distributed in the fresher marshes of Louisiana as described in Section II.D.4. The common buffalofish, *Megastomatobus cyprinella*, feed extensively from the bottom and do not combine their feeding to any depth but frequent those levels where food is to be found.

Three species of gar, long nosed gar, Lepisosteus osseus, short nosed gar, Cylindrosteus platostomus, and the Mississippi Alligator gar, Atractosteus spatula, are considered highly important commercial fish species of Louisiana, but since they too inhabit fresh-brackish water areas, they will not be discussed in detail because of their remoteness from offshore drilling operations.

G. <u>Resources of the Louisiana Coastal Zone and Adjacent Waters</u>

1. <u>Land Use in the Coastal Zone</u>

Land use patterns in coastal Louisiana reflect varied pressures, economic and cultural, on a unique environment - the vast wetlands of the Mississippi delta system and its characteristic bayous, natural levees, cheniers, swamps and marshes. This environment has offered both opportunities and constraints to development.

Opportunities for development offered by the Louisiana coastal area include the presence of rich oil and gas resources, agricultural lands, wildlife resources which support trapping and recreational activities, valuable fishery resources, and the proximity of the Mississippi River which serves as an important transportation route. These opportunities have given rise to industrial, urban, and agricultural development, supporting population increases and bringing stress to the environment in certain areas.

Table 28 indicates the land use in coastal Louisiana by acres. It can be seen that marshlands comprise 63% of the land area of the coastal parishes. These marshlands are essential habitat for numerous economically important species of fish and wildlife and are the site of wildlife refuges and game management areas. However, the marshlands are also vulnerable to impacts from oil and gas operations, urban developments, construction of transportation routes, and industry.

Table 28.

Land Use in Coastal Louisiana
(by No. of acres)

Parish	Total Area	Water Area	Marshland	Forest Land	Agri. Land	Urban Land	Trans-port	Aggregate Land Area	Unac-counted Acreage	Area Percent
Cameron	1,087,360	194,101	739,474	-	269,492	180	2,332	1,011,478	-118,210	-10.9
Iberia	414,080	49,050	115,164	115,000	129,618	5,210	4,805	369,797	-4,767	-1.2
Jefferson	382,720	136,960	157,237	-	7,379	24,030	2,838	191,484	54,276	14.2
Lafourche	865,920	168,239	390,742	156,000	179,339	3,320	3,884	733,285	-35,604	-4.1
Orleans	232,320	112,460	59,930	-	1,055	37,995	30,941	129,921	-10,061	-2.0
Plaquemines	895,360	322,788	494,101	-	53,658	4,515	2,321	554,595	17,977	2.0
St. Bernard	517,120	220,915	275,499	-	11,838	3,065	609	291,011	5,194	1.0
St. Mary	453,760	87,147	172,308	143,000	107,276	5,440	3,549	431,573	64,960	-14.3
Terrebonne	1,144,320	314,883	621,118	122,400	73,183	5,730	5,027	827,458	1,979	0.2
Vermilion	844,800	79,927	402,807	31,600	372,439	3,520	8,214	818,580	-53,707	-6.4
Total	6,837,760	1,686,470	3,428,380	568,000	1,205,277	93,005	64,520	5,359,182		
% of land in study area by type			63%	10.6%	22%	1.7%	1.2%	100%		

Data from (State of Louisiana, 1967)

The problem of land use planning, then, is an important and complex matter in coastal Louisiana, as it is in many other regions. Planning should take into consideration the varied uses of the region, the need for economic growth, population pressures, wise use of renewable and non-renewable resources, and the inherent natural values of the region.

The Center for Wetland Resources at Louisiana State University has developed a proposed land management plan for the Louisiana coastal zone (Gagliano, 1972). Using environmental evaluations as a basis for recommendations, an attempt was made to formulate a development plan for the coastal area. This plan is "proposed as an approach to multi-use development of the resources of the coastal zone that will provide for both growth and development of the area's population and economy, management and use of those renewable and irreplaceable resources which are vital to the nation, the state, and the quality of life of the region's inhabitants." (Gagliano, 1972)

A brief summary of this proposed multi-use management plan is included here in order to present an interpretation of some land use problems and goals in the coastal zone which will receive impacts (identified in the appropriate sections of this statement) from this proposed sale.

In developing this "broad-brush" proposal for multi-use management, two concepts were used as a basis. 1. A corridor-basin relationship,

Legend: Land Use Objectives in the Louisiana Coastal Zone 1/

1	Fresh-Brackish Marsh Areas
2	Barrier Islands, Reefs, and Gulf Shore Areas
3	Controlled Delta Building Areas
4	Estuarine Nursery Areas
5	Rice Growing Areas
6	Aquifer Recharge Areas
7	Fresh Water Basins
	Development Corridors
	Lands Suitable for Development

1/ Interpreted from (Gagliano, 1972)

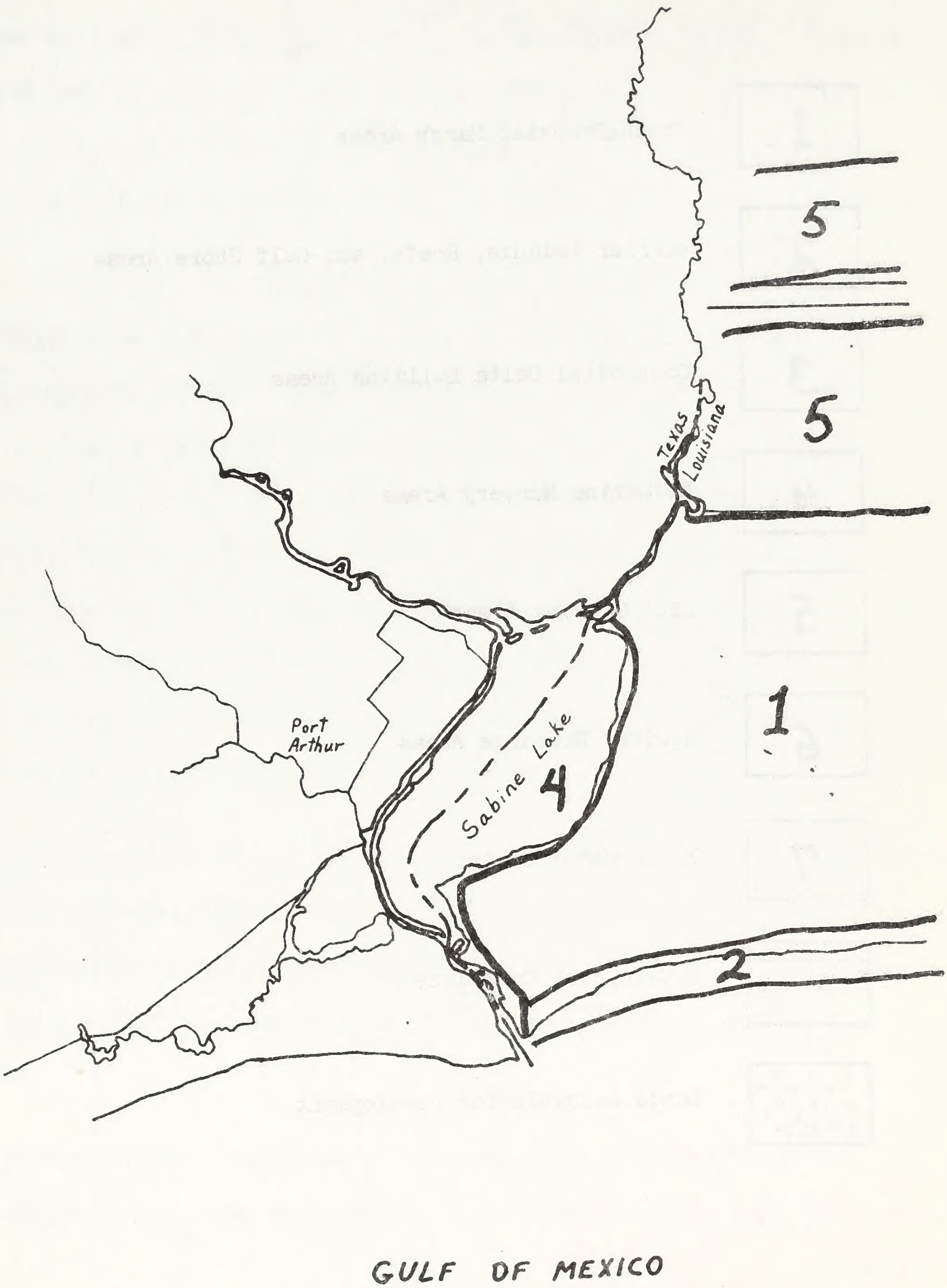


Fig. 33a Land Use Objectives in the Louisiana Coastal Zone

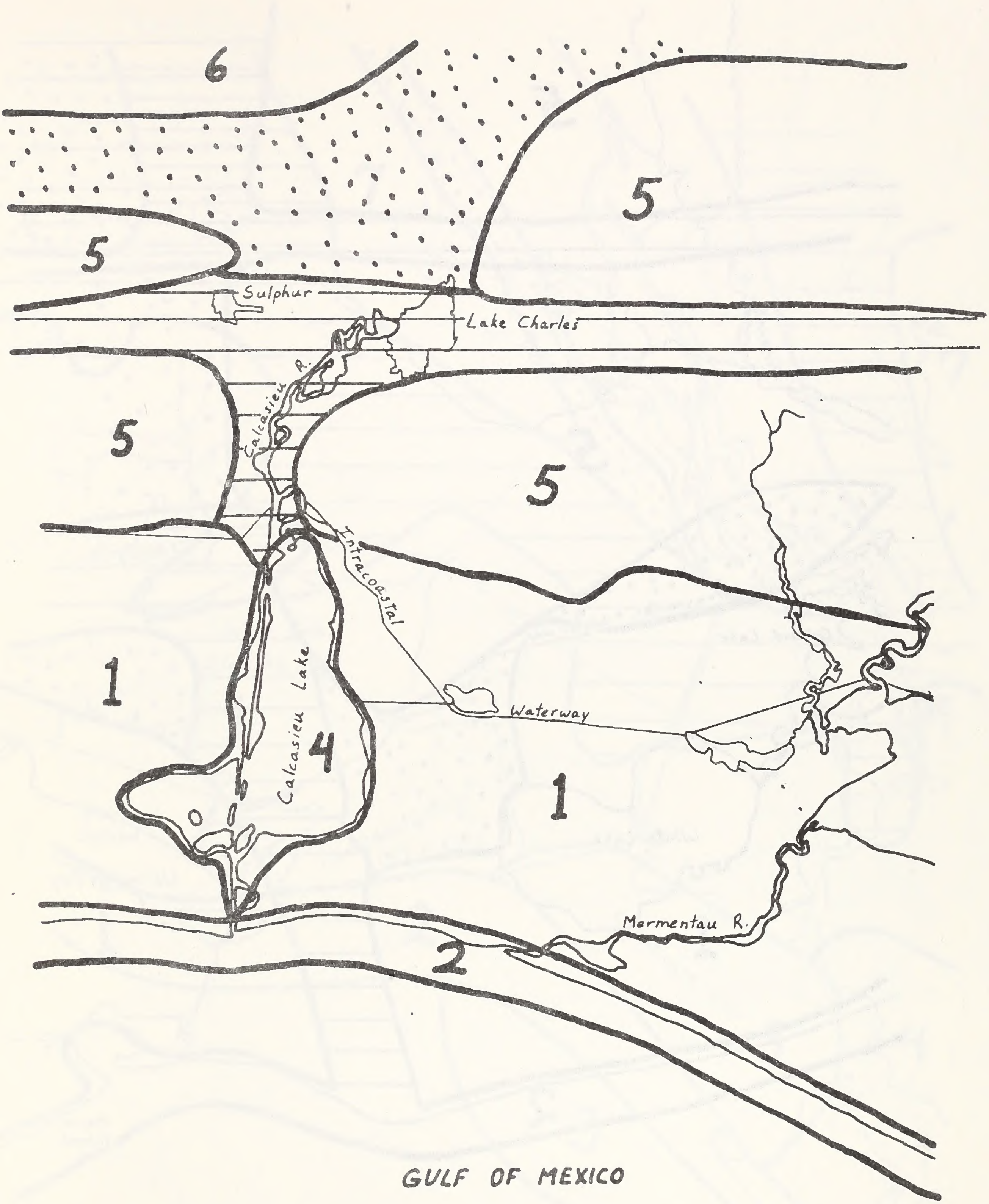

6
5
5
Sulphur
Lake Charles
Calcasieu R.
5
5
Intracoastal
1
Calcasieu Lake
4
Waterway
1
Mermentau R.
2
GULF OF MEXICO

Fig. 33b.

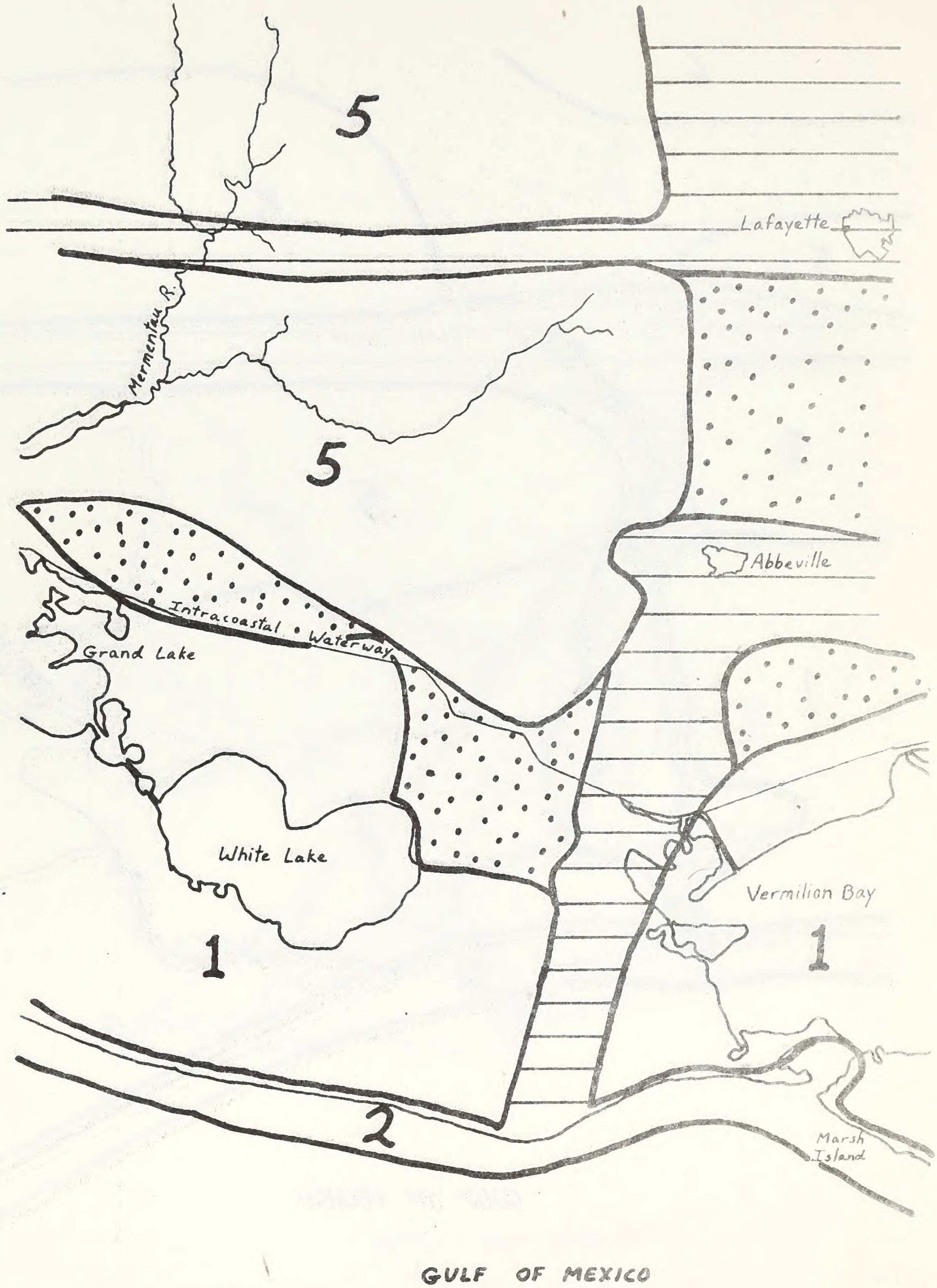

5
Lafayette
Mermentau R.
5
Abbeville
Intracoastal Waterway
Grand Lake
White Lake
Vermilion Bay
1
1
2
Marsh Island
GULF OF MEXICO

Fig. 33c

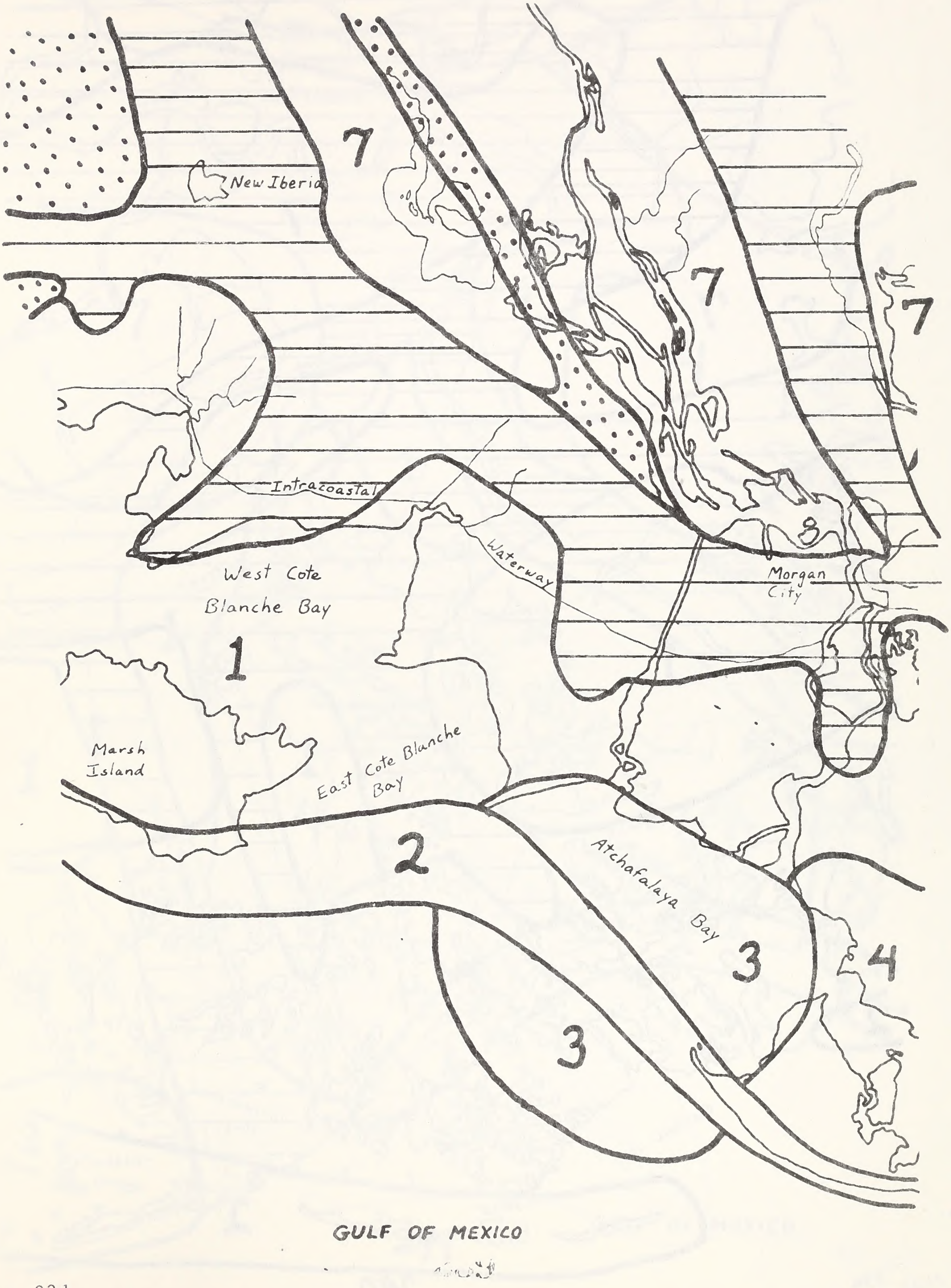
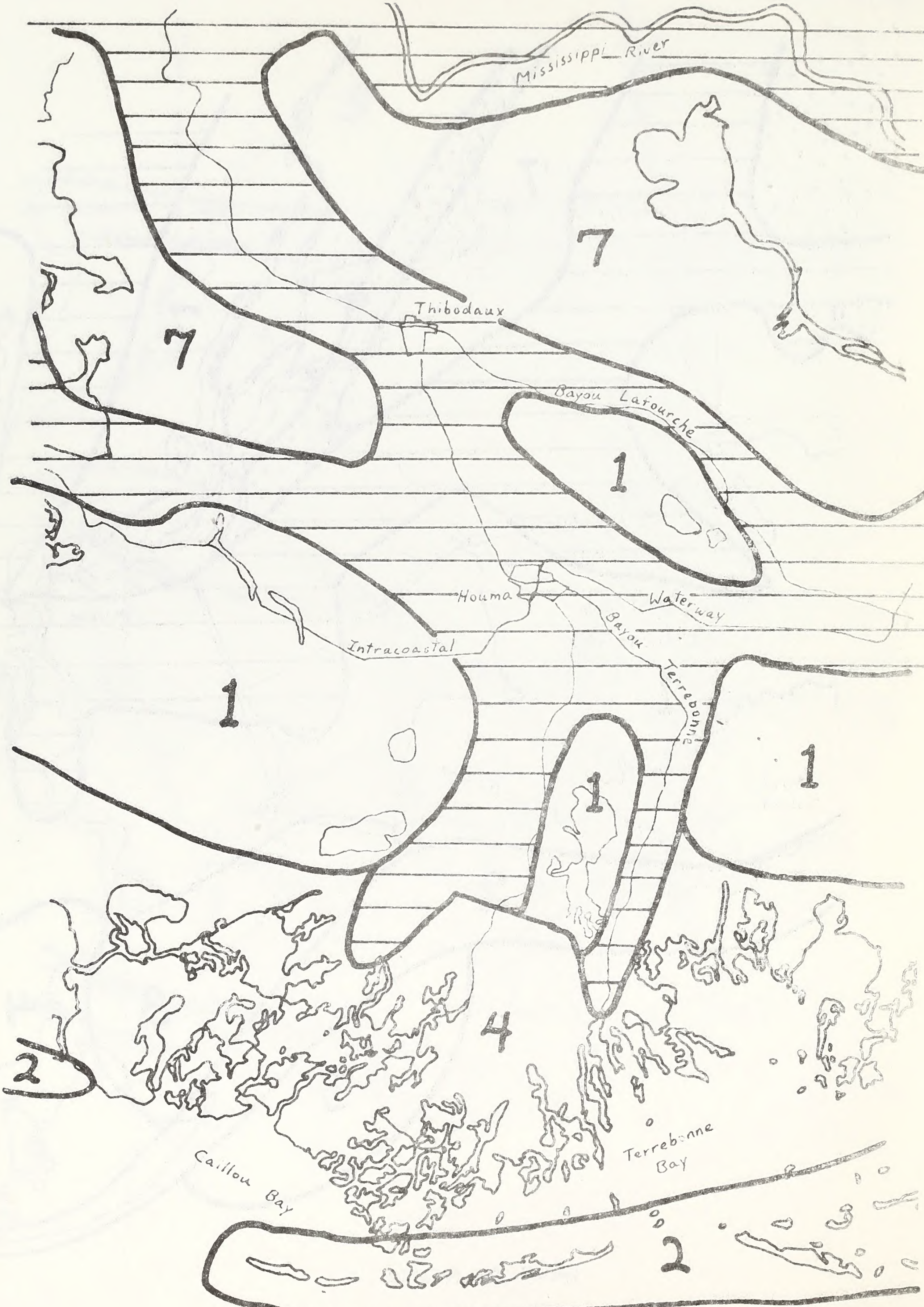
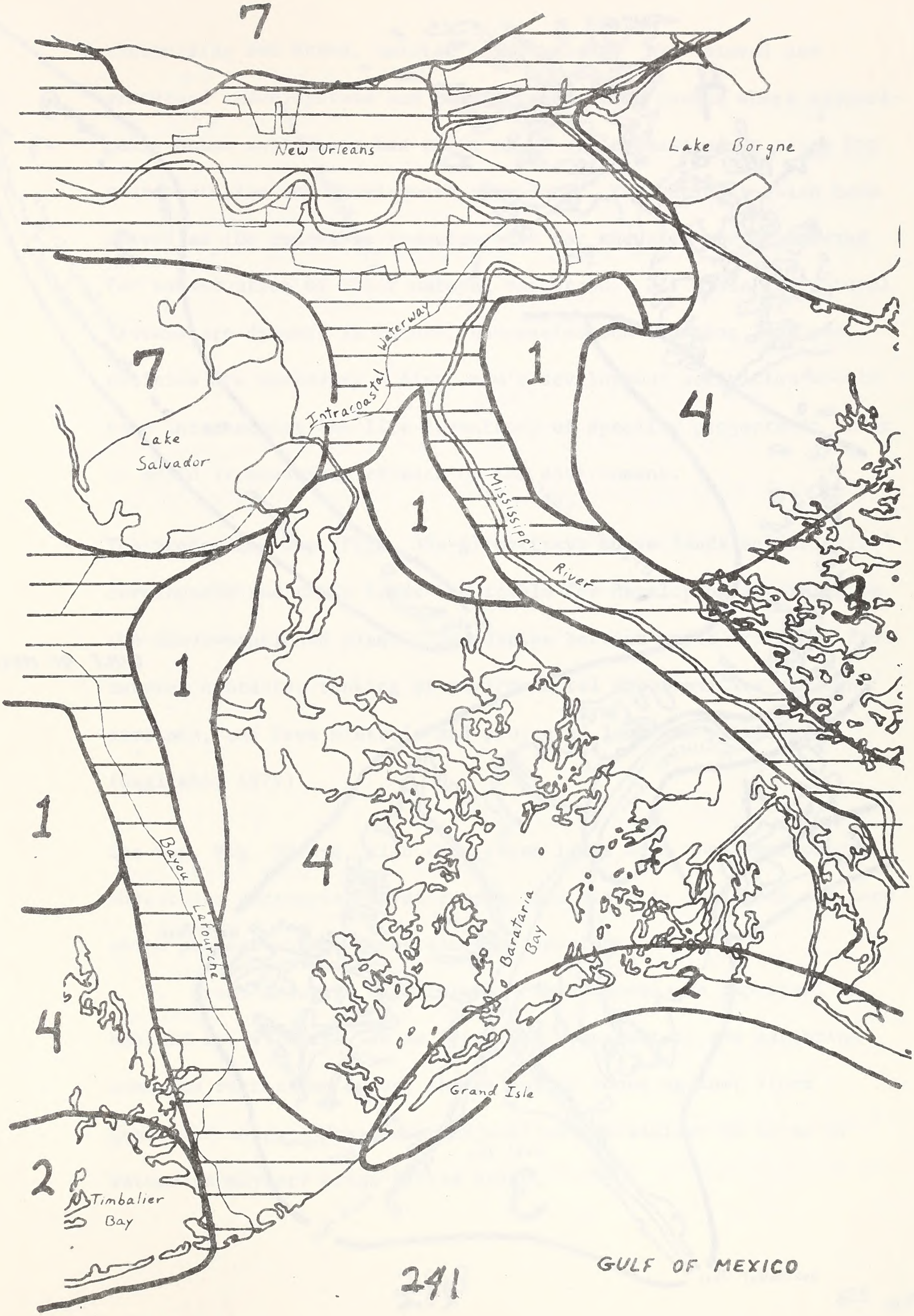

7
New Iberia
7
7
Intrazoastal
Waterway
West Cote
Blanche Bay
1
Morgan
City
Marsh
Island
East Cote Blanche
Bay
2
Atchafalaya Bay
3
3
4
GULF OF MEXICO

Fig. 33d



Mississippi River
7
Thibodaux
7
Bayou Lafourche
1
Houma
Waterway
Intracoastal
Bayou
Terrebonne
1
1
1
4
2
Terrebonne Bay
Caillou Bay
2

Fig. 33e



7
New Orleans
Lake Borgne
7
Intracoastal Waterway
Lake Salvador
1
4
1
Mississippi River
3
1
1
Bayou Lafourche
4
Barataria Bay
2
4
Grand Isle
2
Timbalier Bay
GULF OF MEXICO

Fig. 33f -

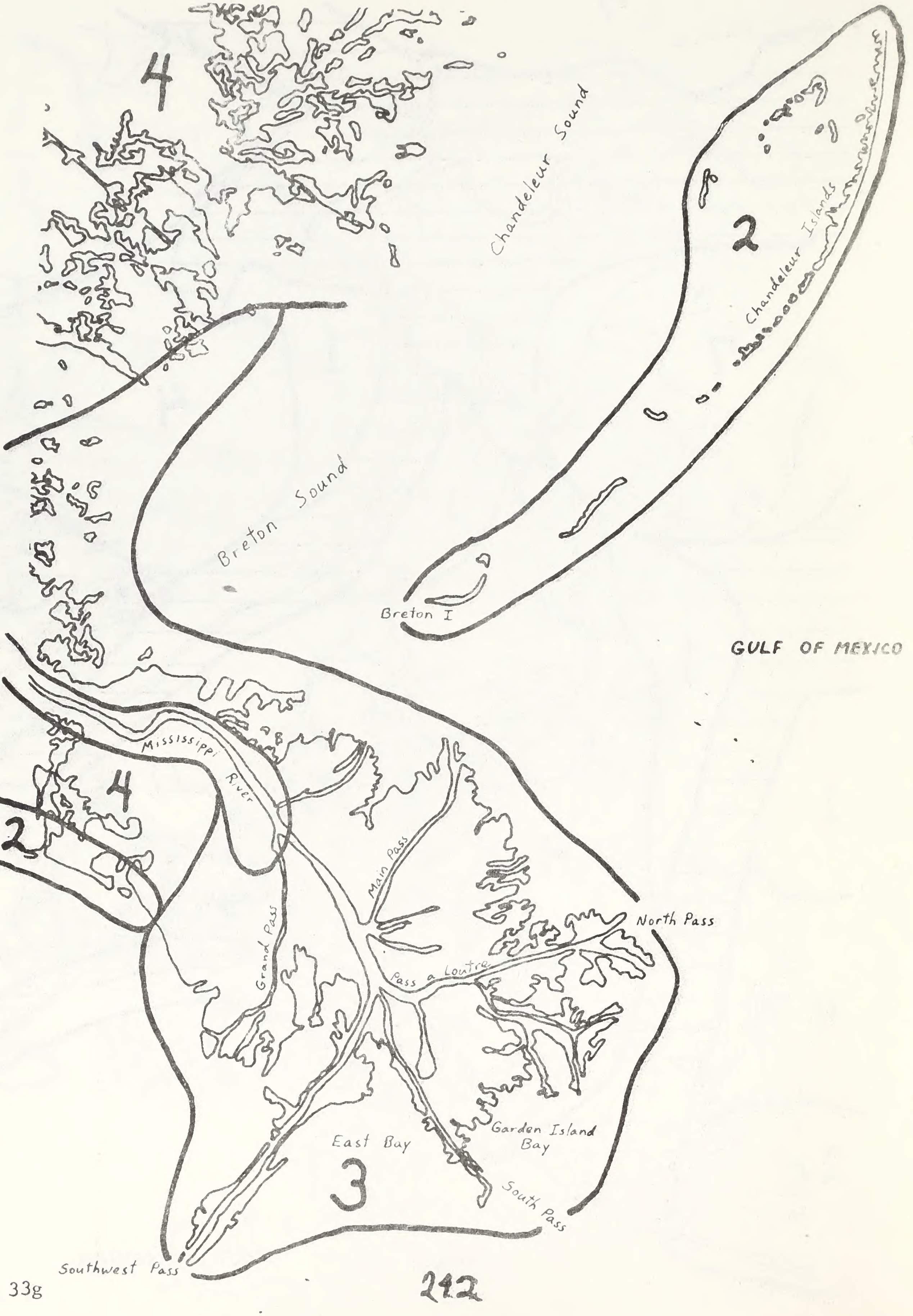

4
Chandeleur Sound
2
Chandeleur Islands
Breton Sound
Breton I
GULF OF MEXICO
Mississippi River
4
2
Main Pass
Grand Pass
North Pass
Pass a Loutre
Garden Island Bay
East Bay
3
South Pass
Southwest Pass

Fig. 33g

recognizing two broad, natural land systems: the natural and protected levee systems and the wetlands. The levees where historically human settlement has taken place are emphasized as sites for transportation and development corridors. The wetlands which have served as the renewable resource base for the area are emphasized for conservation of their natural resources. 2. Since the natural systems are dynamic in nature, successive and changing land use policies are necessary. Also, man's development activities should take into account the life expectancy of specific projects in order to avoid irreversible effects on the environment.

The preceeding map (Figs. 33a-g) portrays those lands suitable for development and those lands unsuitable for developing according to the above-mentioned plan. "Boundaries between units are drawn from natural contacts, ranking of environmental opportunities and constraints, and from historic and projected land use patterns." (Gagliano, 1972)

The map, Fig. 33 a-g, also show those lands with non-developmental objectives portraying physiographic and historic landforms and uses which possess severe constraints to development:

1. Fresh-Brackish Marsh Areas - These areas are important as habitat for wildlife, as an important component of the estuarine zone, as recreation areas, and as buffer zones against storm generated surge. Management objectives are similar to those of estuarine nursery areas listed below.

2. Barrier Islands, Reef, and Gulf Shore Areas - These areas represent the first line of defense against storms and marine processes, regulating inflow and outflow of Gulf water, are valuable as wildlife habitats and recreation areas. They are vulnerable to erosion and hurricane damage. Management priorities - they should be conserved as natural barriers against storms and as wildlife and scenic areas.

3. Controlled Delta Building Areas.

4. Estuarine Nursery Areas. These areas are the most biologically productive areas of the State, essential to the fisheries, and provide wildlife habitat. Management priorities - they should never be drained or reclaimed, marsh restoration programs should be initiated, primary emphasis is on conservation of the renewable resources. Any surface modifications should be made compatible with these objectives.

5. Rice Growing Areas

6. Aquifer Recharge Areas

7. Fresh Water Basins - These areas offer poor foundations for buildings, provide important wildlife habitat, and are important as natural reservoirs ensuring fresh water flow into the estuarine zone. Recommended uses - forestry, fisheries, and recreation. Dredging should be minimized, draining and reclamation prohibited.

The map (Figure 33) also portrays those areas which are "already heavily developed or where development is projected" (Gagliano, 1972).

Shown are Development Corridors and Lands Suitable for Development. Development corridors are primarily confined to land surfaces suited for development such as natural levee systems, but have been expanded in some areas to include lands along major navigation canals or flood protection levees in order to control random expansion into renewable resource areas. Location of corridors also depends on land and water transportation facilities and historic land use patterns. "Development" in these corridors should not imply blanket urbanization or industrialization. Rather, the best mix of land use should be sought.

This summary does not reflect the detail of the study nor all of the problems inherent in any possible future implementation of the plan. For a more specific understanding, the plan itself, "Proposed Multiuse Management Plan for the Louisiana Coastal Zone," (Gagliano, 1972) should be consulted.

2. Recreation Resources

The primary outdoor recreation activities in the Louisiana coastal zone are sportfishing, hunting, camping, birdwatching, boating, and in a few localized areas, beach-oriented activities. Inaccessibility of the coastal marshlands to automobile travelers has limited the development of recreational facilities to a few areas. However, the vast marshlands provide abundant game and fish which attract sport fishermen and hunters.

a. Sportfishing and Recreational Boating

Sportfishing in Louisiana is a very popular form of recreation. Limited access to fishing areas has precluded full utilization of the sport fishery resources, but man-days effort and pounds of catch are impressive. The data used here to portray the intensity of use of Louisiana's sportfishing resource is based on an unpublished report of the results of a telephone survey of 2,270 Louisiana households by the Bureau of Sport Fisheries and Wildlife. Data is for the 1968 season.

The study area was divided into nine hydrologic sub-basins as described below and portrayed on Fig. 34.

Table 29 gives man-days effort and pounds of catch by sub-basin and type of fishing activity. Included are both freshwater and saltwater sportfishing. From this table the success or pounds per man-day effort can be derived. Sub-basin III yields the greatest poundage per man-day, 15.6 pounds. Sub-basin II ranks second, yielding 10.7 per man-day, Sub-basin VII yields about 9.4 pounds, and Sub-basins I and IV yield about 8.6 pounds per man-day. Sub-basin VI offers the least success, only 3 pounds per man-day while the average for all sub-basins is 7.2 pounds per man-day.

Sub-basin	Area
I	The area between Pearl River and Bayou Terre aux Boeuf including Lake Maurepas and Lake Pontchartrain.
II	The area between Bayou Terre aux Boeuf to the Mississippi River.
III	The active Mississippi River Delta south of Bayou Baptiste Coullette and Red Pass.
IV	The area between the Mississippi River and Bayou Lafourche.
V	The area between Bayou Lafourche and the Atchafalaya River.
VI	The area between the Atchafalaya River and Bayou Sale.
VII	The area between Bayou Sale and along the drainage basin line in the vicinity of Freshwater Bayou and northward to Abbeville and Lafayette.
VIII	The area between Freshwater Bayou and the eastern drainage basin for the Calcasieu. This line approximates the line formed by State Highway 27 and north to Iowa, La.
IX	The area of the Calcasieu and Sabine drainage basins.

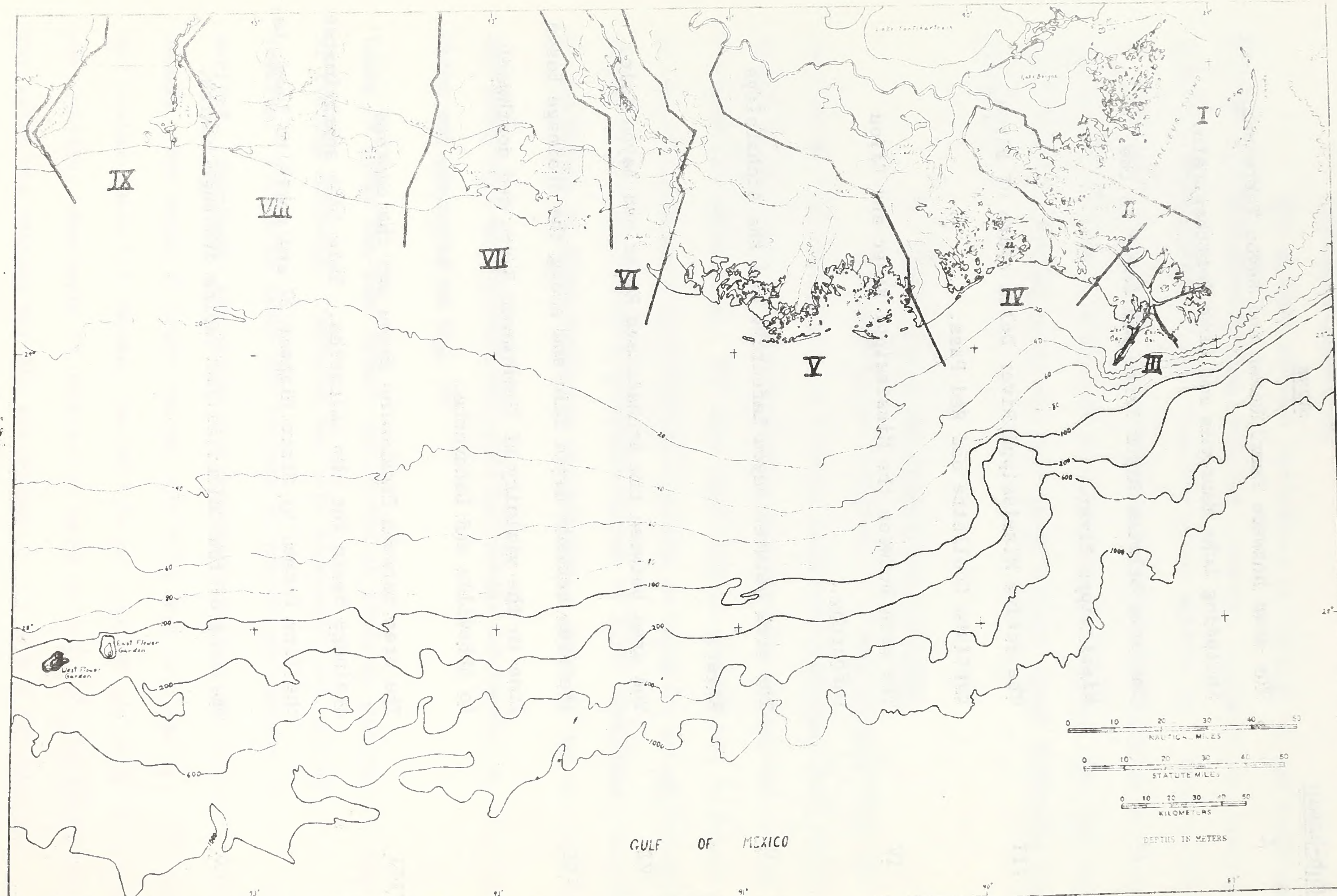


Figure 34. Hydrologic Sub-basins of the Louisiana Coast.

Table 29. 1968 Sport Fishing Louisiana

	ACTIVITY					
	SPORT FINFISHING SALTWATER	SPORT FINFISHING FRESHWATER	SPORT CRABBING	SPORT CRAYFISHING	SPORT SHRIMPING	TOTALS
SUB-BASIN I						
MAN-DAYS	1,730,000	768,000	172,000	21,000	60,000	3,751,000
POUNDS	10,380,000	1,536,000	15,236,000	105,000	3,000,000	30,257,000
SUB-BASIN II						
MAN-DAYS	101,000	26,000	27,000	9,000	18,000	181,000
POUNDS	606,000	52,000	351,000	45,000	900,000	1,954,000
SUB-BASIN III						
MAN-DAYS	39,000	18,000	3,000	*-----	18,000	78,000
POUNDS	234,000	45,000	39,000	*-----	900,000	1,218,000
SUB-BASIN IV						
MAN-DAYS	1,063,000	490,000	497,000	50,000	98,000	2,198,000
POUNDS	6,378,000	980,000	6,461,000	250,000	4,900,000	18,969,000
SUB-BASIN V						
MAN-DAYS	570,000	391,000	115,000	24,000	63,000	1,163,000
POUNDS	3,420,000	782,000	1,495,000	120,000	3,150,000	8,967,000
SUB-BASIN VI						
MAN-DAYS	63,000	1,653,000	58,000	307,000	4,000	2,085,000
POUNDS	378,000	3,306,000	754,000	1,535,000	200,000	6,173,000
SUB-BASIN VII						
MAN-DAYS	185,000	192,000	61,000	31,000	49,000	518,000
POUNDS	1,110,000	384,000	793,000	155,000	2,450,000	4,892,000
SUB-BASIN VIII						
MAN-DAYS	72,000	487,000	56,000	74,000	22,000	711,000
POUNDS	432,000	974,000	728,000	370,000	1,100,000	3,604,000
SUB-BASIN IX						
MAN-DAYS	222,000	229,000	261,000	20,000	41,000	773,000
POUNDS	1,332,000	458,000	3,393,000	100,000	2,050,000	7,333,000
TOTALS						
MAN-DAYS	4,045,000	4,254,000	2,250,000	536,000	373,000	11,458,000
POUNDS	24,270,000	8,517,000	29,250,000	2,680,000	18,650,000	83,367,000

* NO HABITAT AVAILABLE

Data from unpublished report by Bureau of Sport Fisheries and Wildlife, 1968.

As indicated on Table 29 , saltwater finfishing activities are most concentrated in Sub-basins I and IV. Some of the more popular saltwater sport fish are croaker, red drum, sea trout, flounder, tarpon, snappers, and groupers.

Fresh water finfishing activity is concentrated in Sub-basin VI which corresponds to the Atchafalaya River basin. Popular freshwater sport fish include largemouth bass, bluegill, redear, crappie, and catfish.

Surf-fishing is popular along the barrier islands of coastal Louisiana. However, most of these islands are accessible only by boat. Sportfishing around offshore oil and gas rigs is also popular. Therefore, the large number of man-days spent in sport fishing indicates a corresponding high level of boating activity. It can be assumed that the highest levels of recreational boating related to sportfishing will be found in sub-basins I and IV where the most sportfishing activity is concentrated. In September, 1970, there were 101,084 registered boats over 12 feet in length with motors exceeding 10 horsepower in the coastal parishes of Louisiana (Jones and Rice, 1972). This figure includes commercial vessels, but the greatest portion are private recreational boats.

b. Hunting

Hunting for mammals in coastal Louisiana is primarily confined to deer, rabbits, and squirrels. Some sport hunting of raccoons is done, but this is considered nominal in comparison to the other species. These species were included in a statewide telephone survey conducted by the Bureau of Sport Fisheries and Wildlife (BSF&W) for the 1968-69 hunting season. The survey identified sport wildlife, fishing, and wildlife oriented recreational activities for coastal Louisiana and the Atchafalaya Basin. Since most of the Atchafalaya Basin is located far inland, information for this area is added only for the general inventory of the coastal region.

WHITE-TAILED DEER

The white-tailed deer (Odocoileus virginianus) is the only big game mammal of the coastal region with the exception of a few turkeys in the Atchafalaya and Pearl River Basins. All the coastal parishes provide some deer hunting with the exception of Orleans. Average carrying capacity is low, only one deer per 82 acres. This is due primarily to the generally poorer habitat in the coastal marshes as compared to the bottomland hardwoods of upland areas. Deer hunters expended 240,000 man-days of effort during the 1968-69 season. Activity was highest in

Hydrologic Unit VI (144,000 man-days) which includes the Atchafalaya Basin. The next highest unit was Unit VII (48,700 man-days) which, like Unit VI, contains forest habitat.

RABBIT

Two species of rabbits are sought by hunters in the coastal and nearby upland areas of Louisiana. These are the cottontail (*Sylvilagus floridanus*) and the swamp rabbit (*S. aquaticus*). Cottontails are primarily found in well-drained areas such as furrows, woodlots, and miscellaneous woody areas. Swamp rabbits prefer wooded swamps and spoil banks in the marshes.

Rabbits are the most popular game mammal in the coastal area. Most hunting activity occurs in bottomland hardwoods and fresh and intermediate marsh vegetative types. An estimated 693,000 man-days were expended hunting them in the coastal region. Most hunting was done in Hydrologic Unit VI with 176,900 man-days. Other areas supporting high amounts of rabbit hunting activity were units V, IV, and VII.

SQUIRREL

Two species of squirrels are found in the coastal area. These are the gray squirrel (<u>Sciurus carolinensis</u>) and the fox squirrel (<u>S. niger</u>). They are found throughout the coastal and nearby upland region wherever suitable forested habitat occurs.

The 1968-69 BSF&W telephone survey indicated 419,700 man-days expended squirrel hunting in the coastal region of Louisiana making it the third most popular hunting activity in the area. As could be expected, Unit VI led all other areas with an estimated 187,200 man-days. Other areas which supported a substantial amount of squirrel hunting activity were units VII and VIII.

Bird hunting in Louisiana is extensive, especially in the coastal marshes. Birds hunted for sport include doves, quail, turkeys, ducks, geese, snipe, rails, coots, woodcock, and gallinules.

Table 30 shows the estimated man-days efforts of bird hunting for each of the nine hydrologic units along coastal Louisiana during the 1968-69 season. Quail and dove hunting in coastal Louisiana amounted to an estimated 276-000 man-days activity. The majority of this activity occurred in Unit VI which includes the Atchafalaya Basin. Duck and geese hunting activity amounted to an estimated 655,800 and 123,600

Table 30.

Hunting Effort in 1,000 of Man-Days in Coastal Louisiana By Sub-Basins During 1968-69 Season. (Unpublished BSF&W Telephone Survey Data.)

Sub-Basin	Squirrels	Rabbits	Quail & Dove	Other Small Game	Deer & Turkeys	Duck	Geese	Other Marsh Birds
I	29.4	68.5	18.5	2.2	17.6	66.0	6.6	1.9
II	0	0	0	0	1.2	3.9	0	0
III	0	0	0	0	0	12.0	6.0	8.8
IV	31.2	108.0	5.6	0	3.5	68.7	0	16.4
V	43.0	131.6	17.6	0	6.4	64.0	5.1	4.6
VI	187.2	176.9	13.9	13.5	144.0	81.7	4.6	0
VII	50.3	92.4	133.1	12.6	48.7	82.9	17.8	4.7
VIII	55.3	59.4	58.0	1.3	15.4	140.4	54.8	0
IX	23.4	56.1	29.2	5.2	3.6	135.4	28.7	1.5
TOTALS	419.7	693.0	276.0	34.7	240.4	655.8	123.6	37.9

Man-days (1000's)

man-days respectively for coastal Louisiana. Most geese and duck hunting occurred in units VII and IX, the Chenier Plain area in southwestern Louisiana.

More recent information on duck hunting in Louisiana has been compiled by Louisiana Wildlife and Fisheries Commission. They divided the state into 6 areas (Fig. 35) and surveyed duck hunting in the state. Table 31 shows the results of the total 1971-72 waterfowl hunting season in Louisiana. From the survey (published in U.S. Army Corps of Engineers, App. F, 1973) 70% of the total ducks killed in the state came from areas 1 and 2 which generally cover the coastal marshes.

In the 1971-72 waterfowl season in Louisiana an estimated 91,980 people hunted for a total of 802,144 days. Each hunter made an average of 8.7 hunting efforts during the season. Approximately 568,079 coots were killed, an average of 6.2 per hunter. The total number of ducks killed was 2,160,843 or 23.5 per hunter and 2.7 per effort. Most of the ducks killed were mallard, 19%. Green-winged teal accounted for 14%, blue-winged teal for 13%, pintail for 11%, wood ducks for 10%, gadwall for 8%, widgeon for 7%, scaup for 6%, shoveler for 4%, and mottled ducks for 3%.

c. Outdoor Recreation Areas, Historical and Archeological Sites

Included under this heading are Federal and state wildlife refuges, game management areas, state parks, natural beaches used

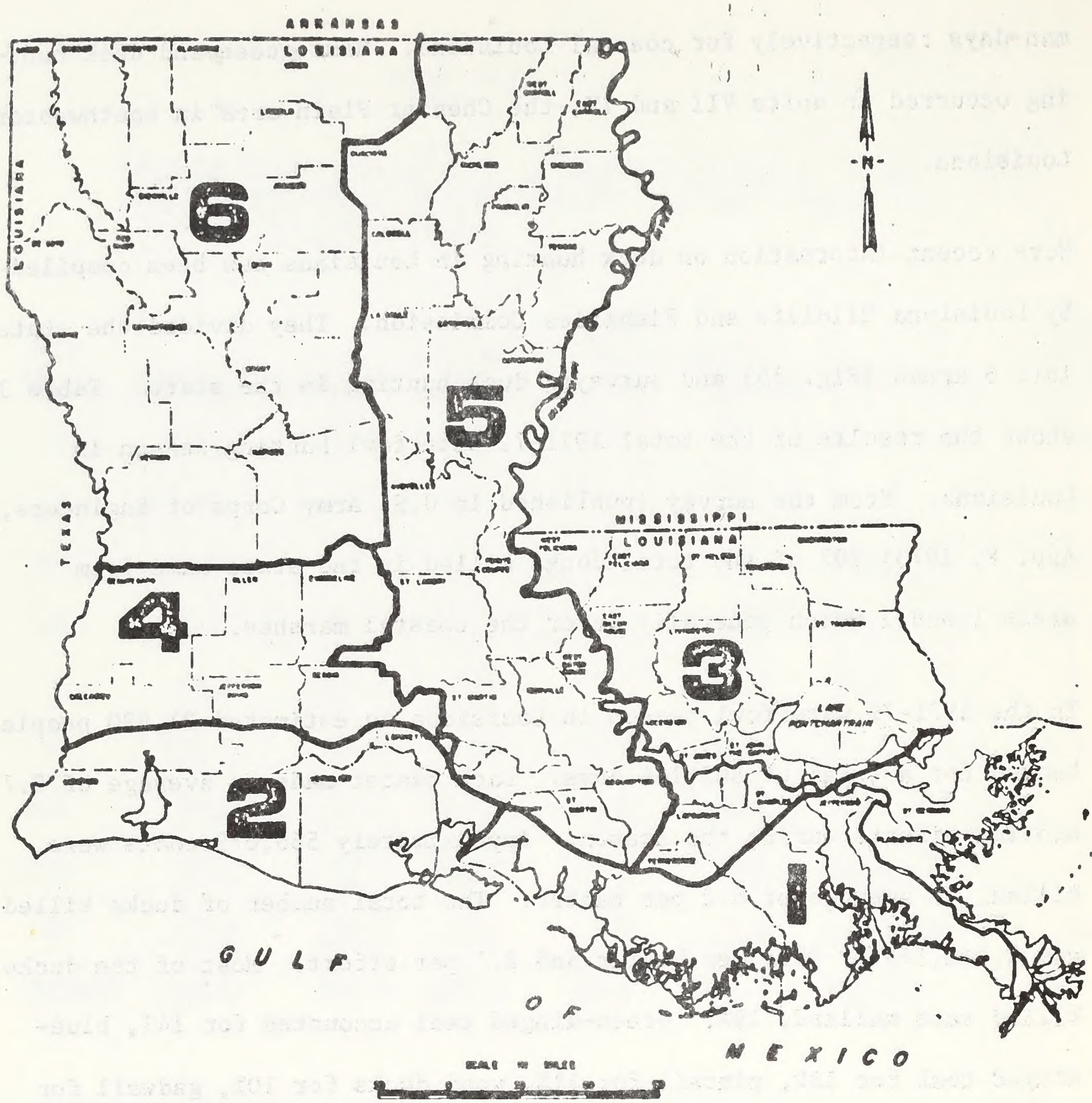


Figure 35.

Subdivision of Louisiana for waterfowl kill survey, 1971-72. (from unpublished data, Louisiana Wildlife and Fisheries Commission). 1/

1/ Figure taken from U.S. Army Corps of Engineers, Appendix F, 1973.

Table 31.

Estimates of Waterfowl Hunting Activities During 1971-72 Waterfowl Hunting Season in Louisiana. Estimates for Early Teal Season and Two Segments of Regular Season. (From Louisiana Wildlife and Fisheries Commission, unpublished.) 1/

Item	Estimate*
Waterfowl Hunters	91,980
Early Teal Season	26.366
Regular Season	90,910
Days Hunted	
Early Teal Season	68,584
Regular Season	733,560
Total Days Hunted	802,144
Total Coots Hunted	568,079
Ducks Killed:	
Mallard	423,043
Green-winged teal	303,770
Pintail	237,599
Blue-winged teal	292,836
Wood Duck	216,264
Gadwall	177,239
Widgeon	142,382
Shoveler	93,602
Scaup	128,352
Mottled Duck	58,502
All other ducks & Unidentified	82,254
Total Ducks Killed (Combined Seasons)	2,160,843

*70% of estimated harvest from Areas 1 and 2 (Fig. 42)

1/ Table taken from U.S. Army Corps of Engineers, Appendix F, 1973.

for recreation, ornamental gardens, and historical and archeological sites. All of these provide opportunities for outdoor recreation. Much of Louisiana's coastal lands and barrier islands has been designated by Federal, State, or private authorities for the purpose of providing refuge for wildlife and for the management of numerous species, some of which may be threatened or endangered.

The primary purposes of wildlife refuges are, of course, to provide sanctuaries for wildlife, by preserving breeding grounds and habitat which may be becoming scarce in other areas due to encroachment on natural habitats by agricultural, industrial, or urban development, and to provide opportunities for the scientific study of various species of wildlife and for the management and control of their populations. This does not imply, however, that these areas are pristine environments. Alterations of the environment, such as water impoundments, selective burning of vegetation, and construction of canals and levees, have occurred in many of these areas for the purpose of wildlife management as well as for oil and gas exploration and production.

Secondarily, wildlife refuges and management areas provide recreation opportunities such as hunting, fishing, birdwatching, sightseeing, and even camping in some areas. Similarily, although historical and archeological sites provide opportunities for outdoor recreation, these are primarily conservation resources, preserved for their cultural and education values.

The following is an inventory of the principle outdoor recreation areas in coastal Louisiana. Each entry is coded for identification on the following series of maps (Figs. 36 a-g.).

LEGEND: WILDLIFE REFUGES AND OUTDOOR RECREATION AREAS

Federal Wildlife Refuges

State Wildlife Refuges

State Wildlife Management Areas

Private Wildlife Refuges

Parks and Ornamental Gardens

Natural Beach Areas

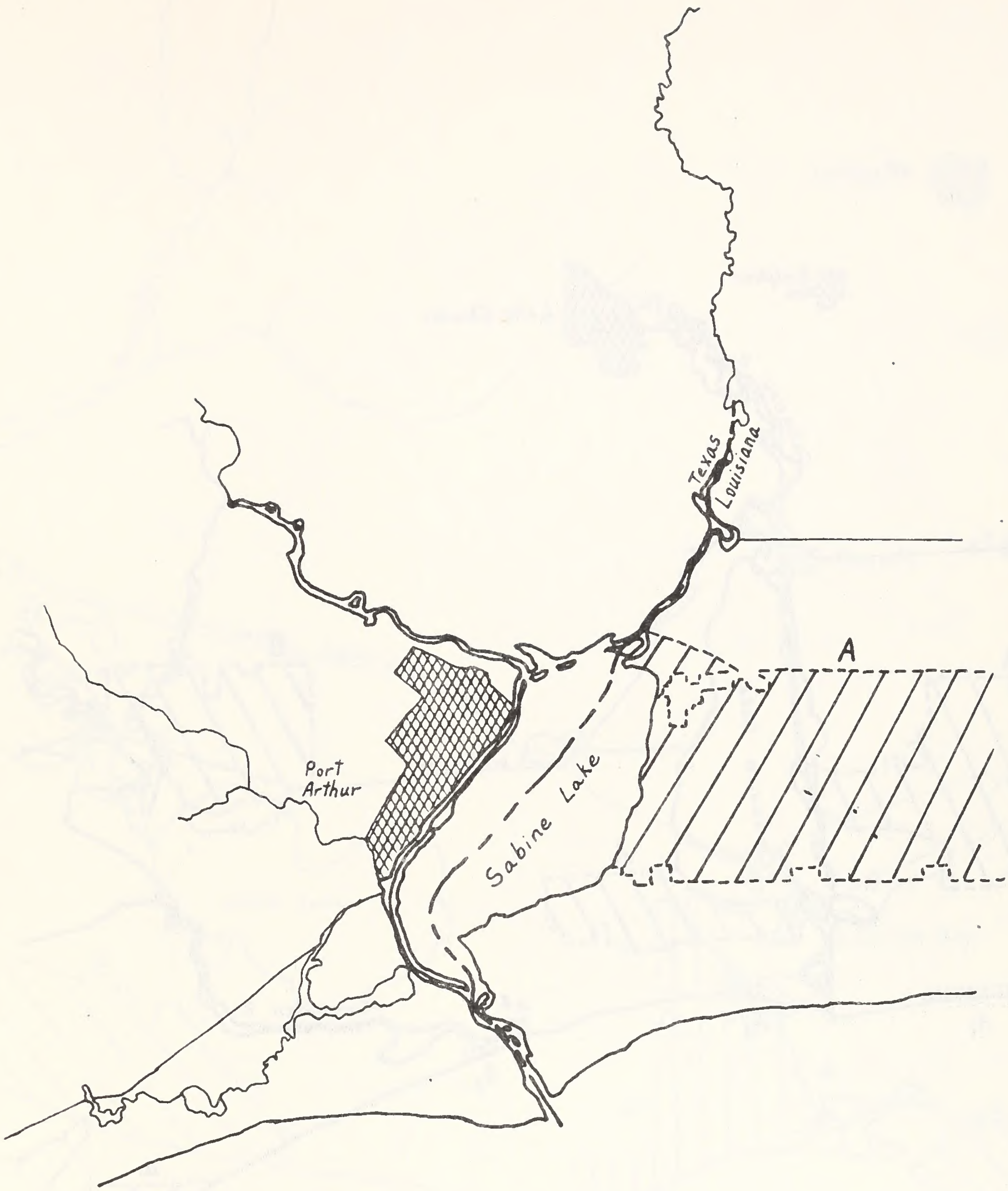


Figure 36 -a.

GULF OF MEXICO

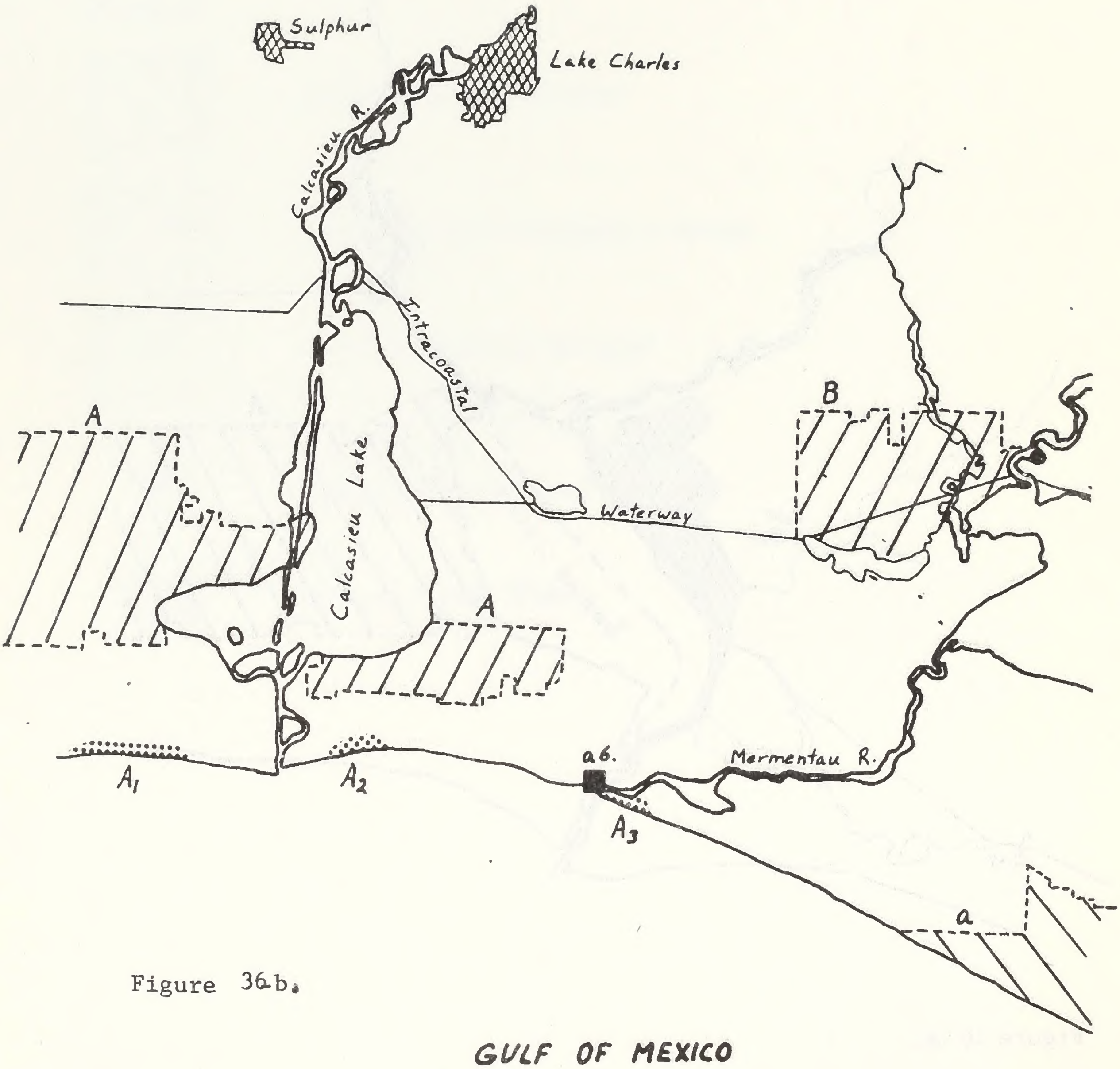

Sulphur
Lake Charles
Calcasieu R.
Intracoastal
Waterway
Calcasieu Lake
A
A
B
A_1
A_2
a6.
Mermentau R.
A_3
a
GULF OF MEXICO

Figure 36b.

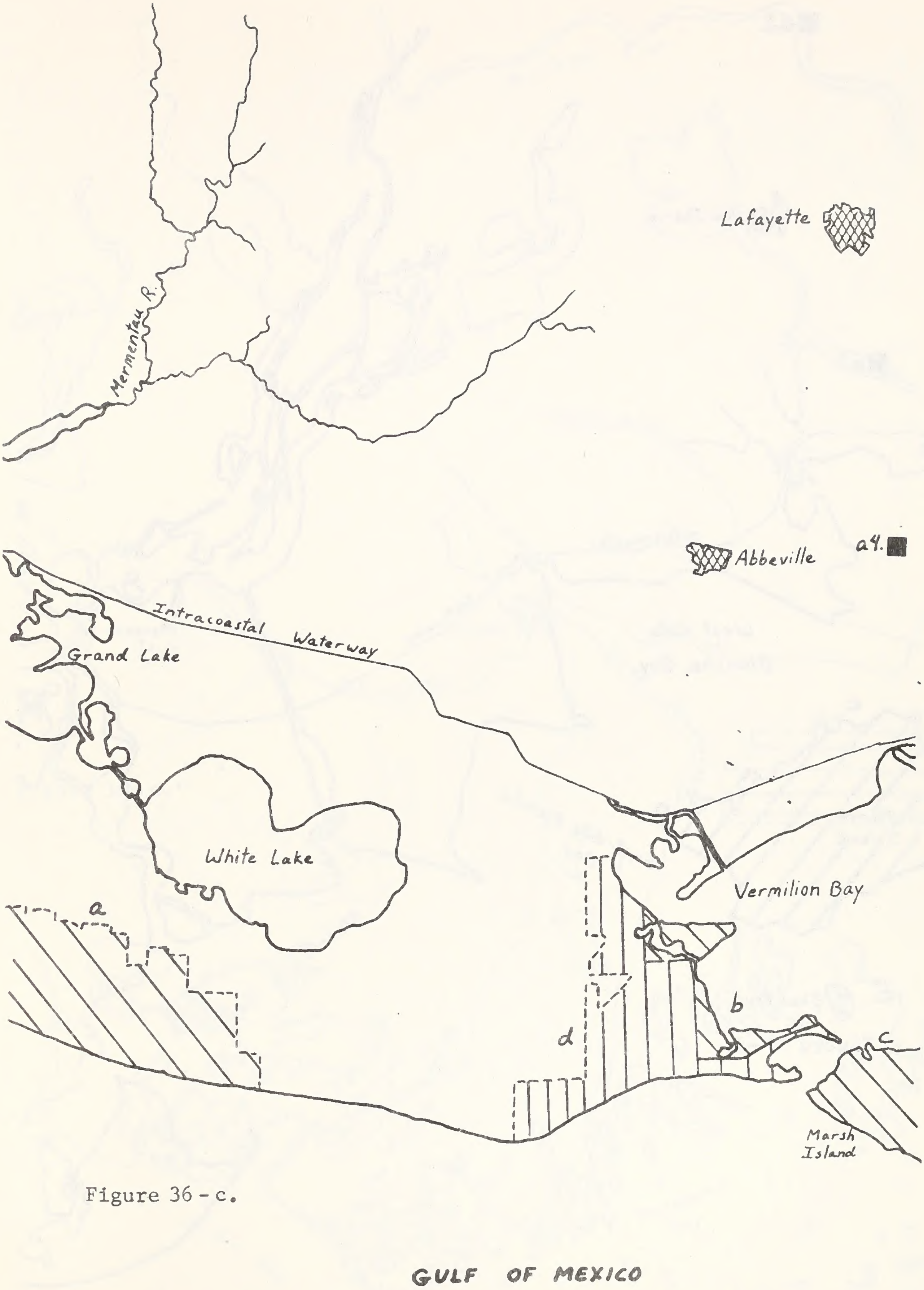

Lafayette
Mermentau R.
Abbeville
a4.
Intracoastal Waterway
Grand Lake
White Lake
Vermilion Bay
a
b
c
d
Marsh Island
GULF OF MEXICO

Figure 36 - c.

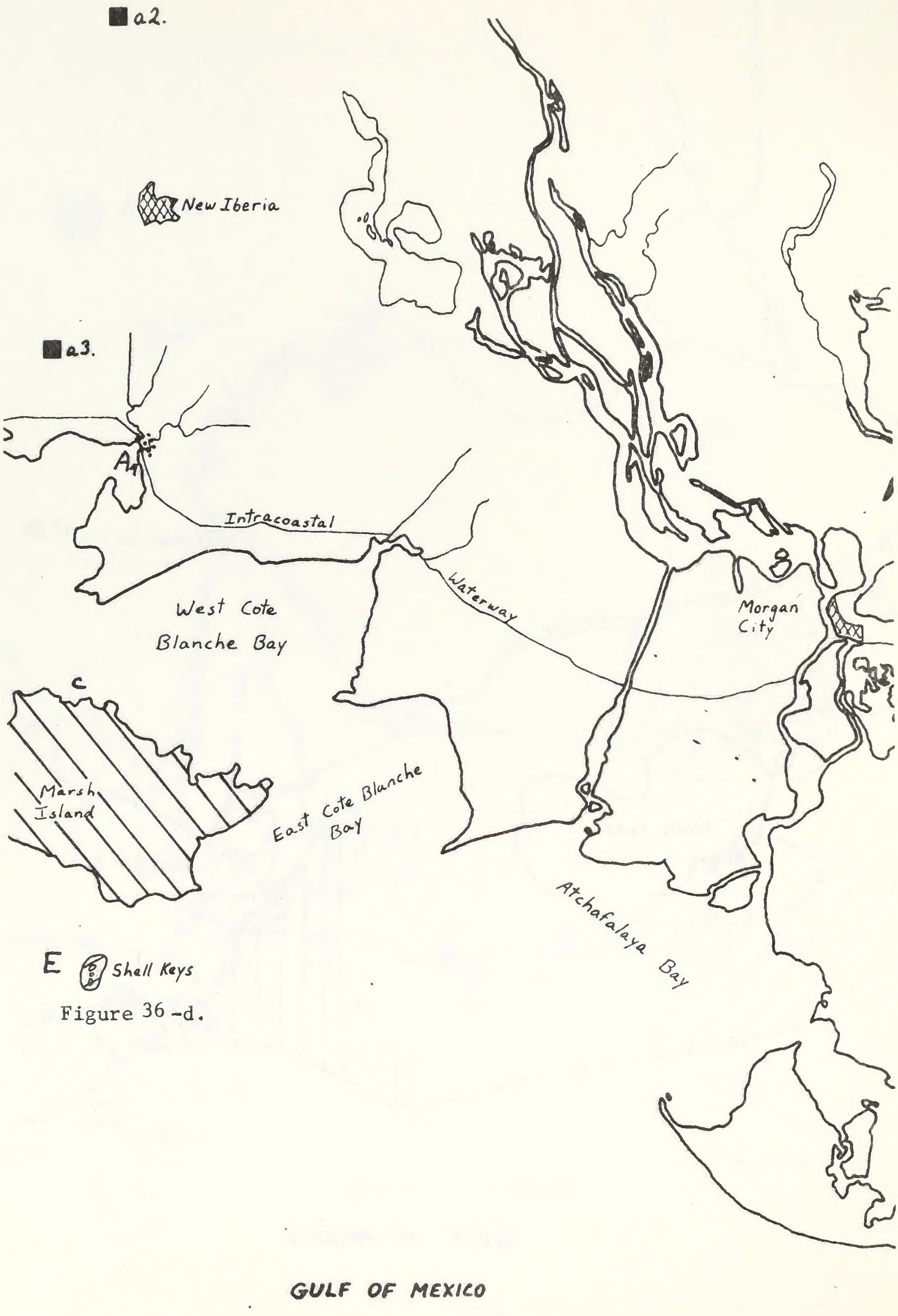

a2.
New Iberia
a3.
A1
Intracoastal
Waterway
West Cote
Blanche Bay
Morgan
City
C
Marsh
Island
East Cote Blanche
Bay
Atchafalaya Bay
E
Shell Keys
GULF OF MEXICO

Figure 36 -d.

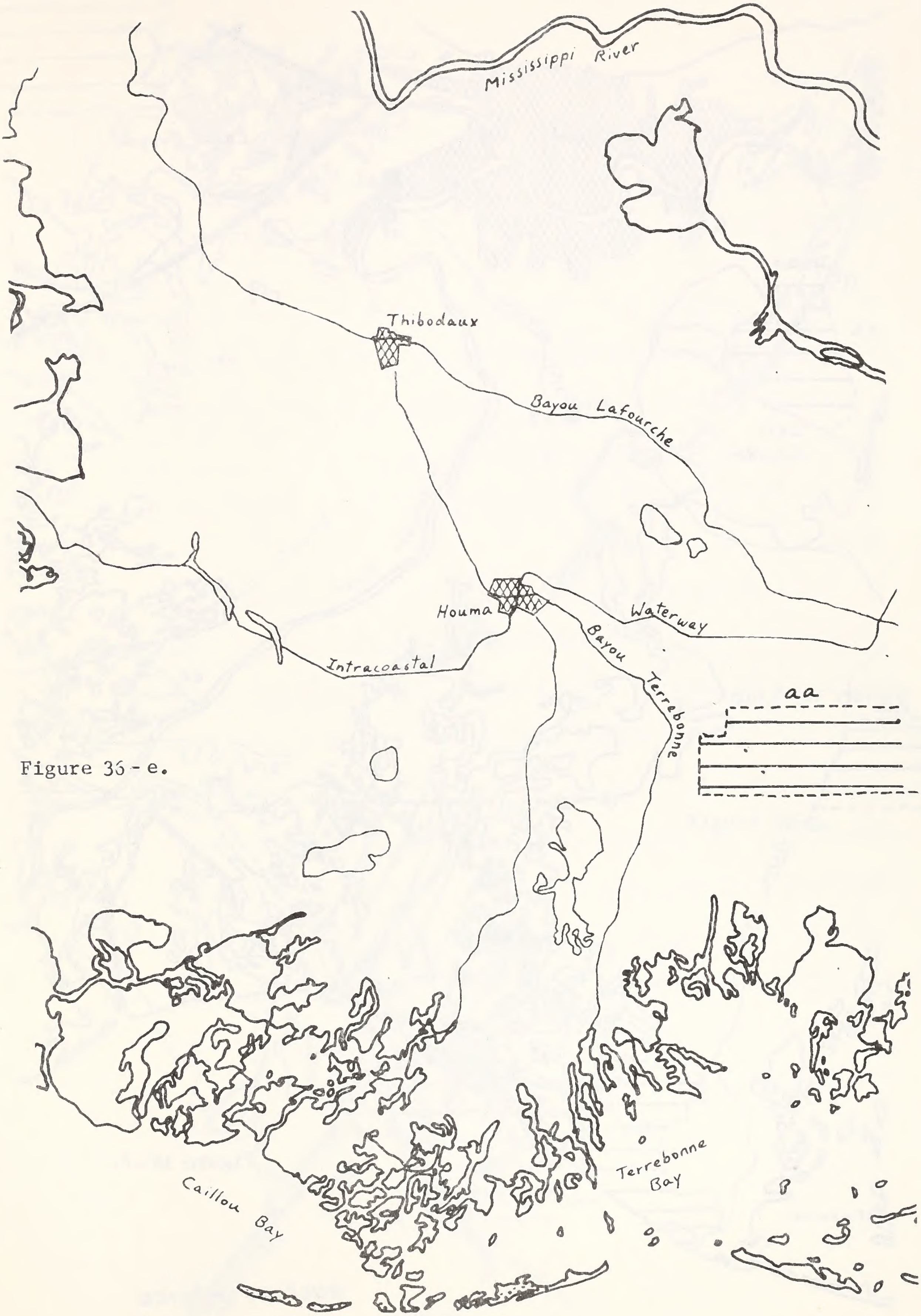

Mississippi River
Thibodaux
Bayou Lafourche
Houma
Waterway
Intracoastal
Bayou Terrebonne
aa
Terrebonne Bay
Caillou Bay

Figure 36 - e.

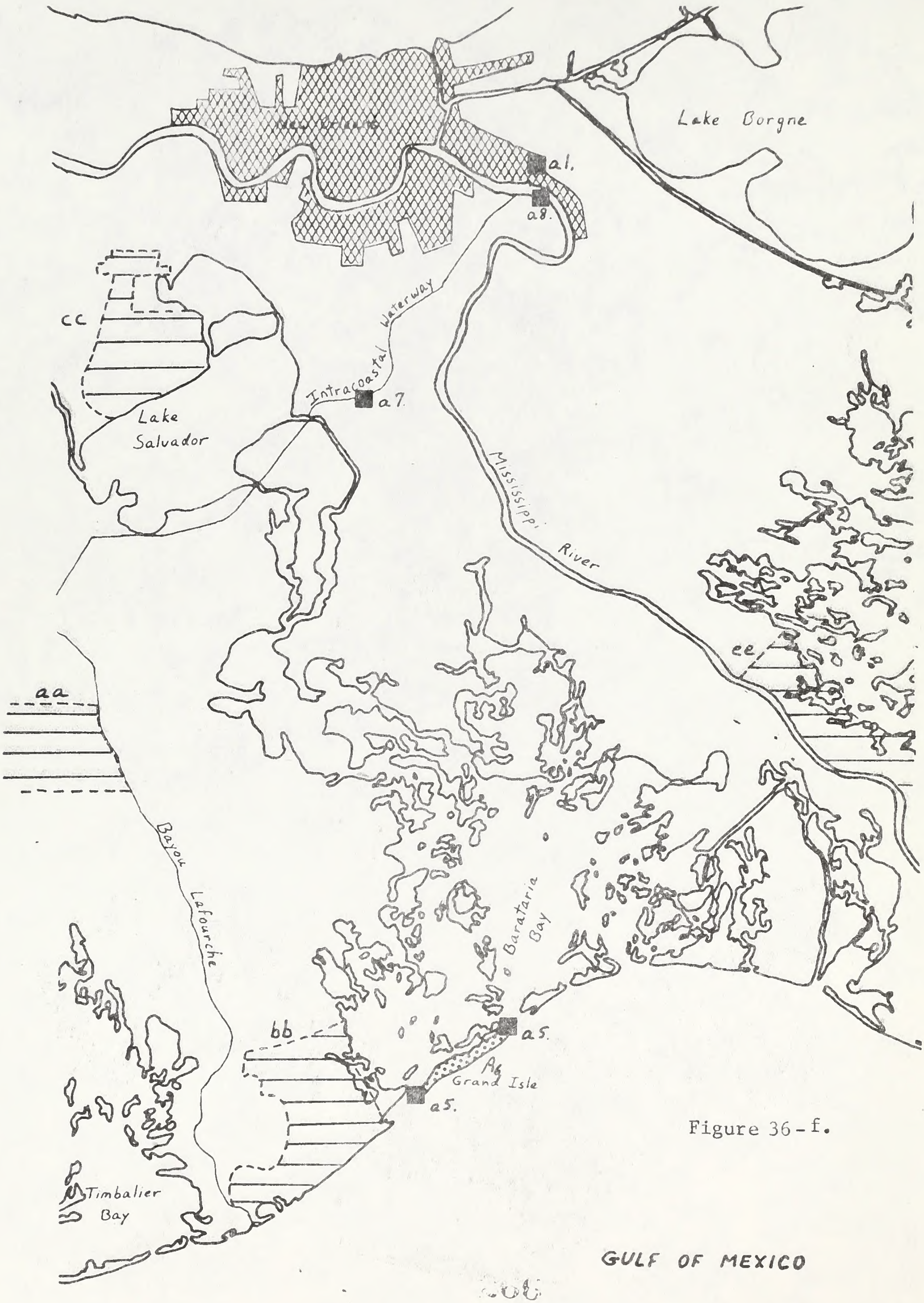

Lake Borgne
a1.
a8.
cc
Intracoastal Waterway
a7.
Lake
Salvador
Mississippi
River
ee
aa
Bayou
Lafourche
Barataria
Bay
bb
a5.
A6
Grand Isle
a5.
Timbalier
Bay
GULF OF MEXICO

Figure 36-f.

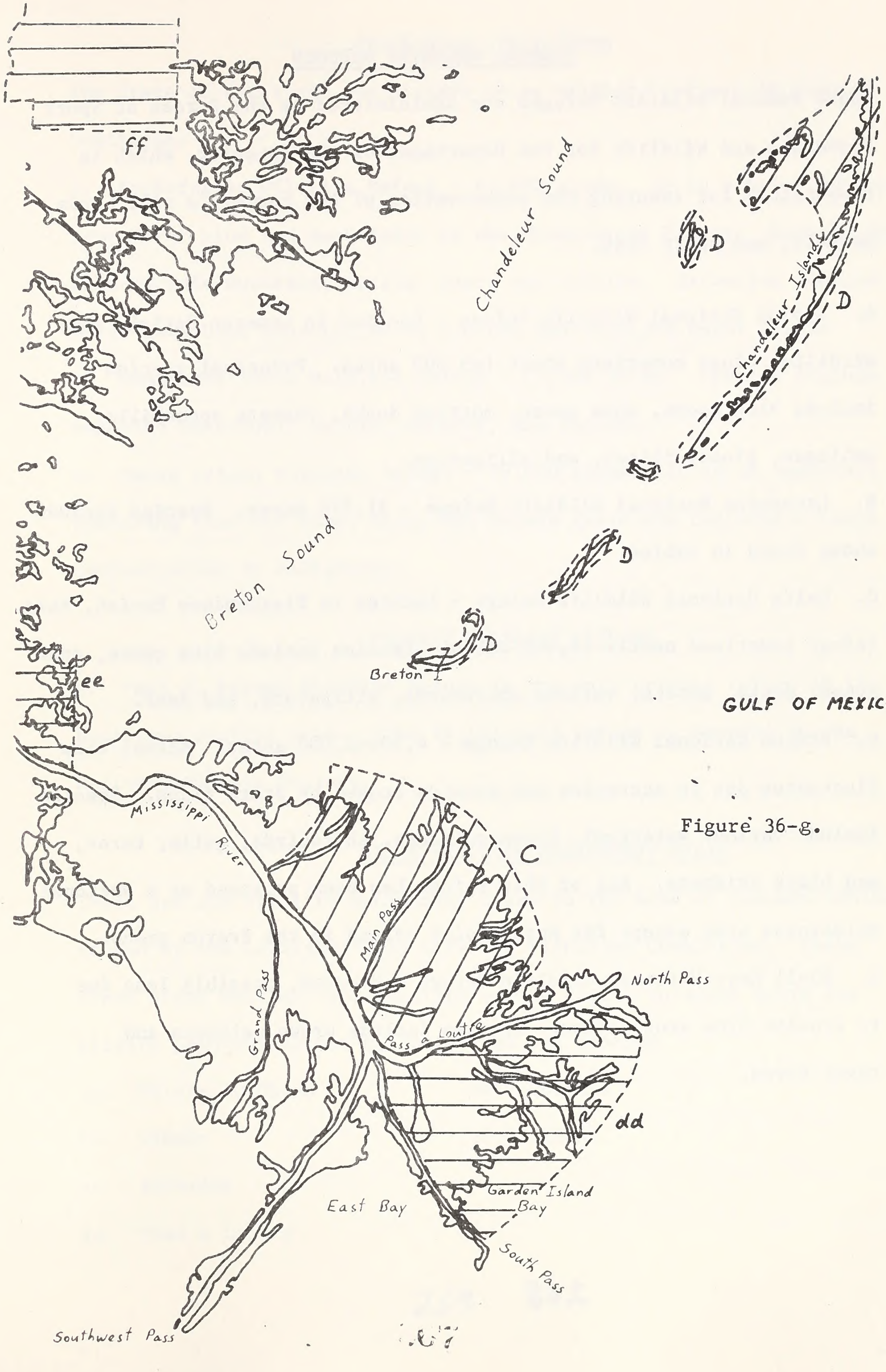

ff
Chandeleur Sound
D
Chandeleur Islands
D
Breton Sound
D
D
Breton I
ee
GULF OF MEXICO
Mississippi River
B
C
Main Pass
Grand Pass
North Pass
Pass a Loutre
dd
Garden Island Bay
East Bay
South Pass
Southwest Pass

Figure 36-g.

FEDERAL WILDLIFE REFUGES

These Federal wildlife refuges are administered by the Bureau of Sport Fisheries and Wildlife for the Department of the Interior, which is responsible for insuring the conservation of the country's wild birds, mammals, and sport fish.

A. Sabine National Wildlife Refuge - Located in Cameron Parish, this wildlife refuge comprises about 143,000 acres. Principal species include blue geese, snow geese, mottled ducks, roseate spoonbills, anhingas, glossy ibises, and alligators.

B. Lacassine National Wildlife Refuge - 31,776 acres. Species include those found in Sabine.

C. Delta National Wildlife Refuge - Located in Plaquemines Parish, this refuge comprises nearly 49,000 acres. Species include blue geese, snow geese, ducks, egrets, various shorebirds, alligators, and deer.

D. Breton National Wildlife Refuge - 4,500-5,000 acres. Actual size fluctuates due to accretion and erosion caused by storm tides. Species include various waterfowl, brown pelicans, shorebirds, gulls, terns, and black skimmers. All of this refuge has been proposed as a National Wilderness area except for North Point Island in the Breton group.

E. Shell Keys National Wildlife Refuge - 8 acres, possibly less due to erosion from storm tides. Species include brown pelicans and royal terns.

STATE WILDLIFE REFUGES

The State of Louisiana administers three wildlife refuges in coastal Louisiana.

a. Rockefeller Wildlife Refuge - 82,000 acres. It is a major wintering ground for blue and snow geese in the Mississippi Flyway. Mammals found here include muskrats, nutria, deer, and rabbits. Extensive impoundments have been constructed to control and regulate water levels.

b. Louisiana State Wildlife Refuge - 15,000 acres. Species include numerous waterfowl, nutria, muskrat, and raccoon.

c. Marsh Island Wildlife Refuge - 79,000 acres. It is an important wintering area for blue, snow, and Canada geese and contains a large concentration of alligators.

PRIVATE WILDLIFE REFUGES

d. Paul J. Rainey Wildlife Refuge is the only private refuge in the Louisiana coastal area. This 26,161 acre refuge is managed by the National Audubon Society.

STATE WILDLIFE MANAGEMENT AREAS

There are six wildlife management areas in the area of concern administered by the Louisiana Wild Life and Fisheries Commission. These areas offer hunting opportunities to the public in areas where the wildife populations can be controlled and managed.

aa. Pointe Au Chien	ee. Bohemia
bb. Wisner	ff. Biloxi
cc. Salvador	
dd. Pass A Loutre	

PARKS AND ORNAMENTAL GARDENS

a1. Chalmette National Historical Park

a2. Evangeline State Park

a3. Avery Island Jungle Gardens

a4. Rip Van Winkle Gardens

a5. Grand Isle State Park

a6. Rutherford Beach State Park

a7. Rose Thorne Park

a8. St. Bernard State Park (under development)

NATURAL BEACH AREAS AND OTHER OUTDOOR RECREATION AREAS

The three areas in coastal Louisiana which have experienced the most beach-oriented recreational development are Grand Isle, Vermilion Bay, and the southwest Louisiana coastline between Holly Beach and the mouth of the Mermentau River. Although there are many miles of beach shoreline, a large portion of it is very narrow, of poor recreational quality, and generally inaccessible.

Grand Isle is Louisiana's principle developed beach comprising about seven miles of Gulf beach ranging from 25 to 400 feet in width. Grand Isle State Park located on two tracts, one on each end of the island provides the public recreational facilities. The most popular activities are swimming and surf fishing.

Cypremort Beach and camping areas are the principle recreational developments along the eastern shore of Vermilion Bay.

In southwest Louisiana there are four beaches along the coast which have been developed by private interests. These are Ocean View, Constance, Peveto, and Holly Beaches. Development here consists of summer homes and small commercial establishments. Rutherford Beach

State Park, at the mouth of the Mermentau River provides recreational opportunities, both day-use and camping. Access to the southwest Louisiana beaches is from Louisiana Highway 82.

Other outdoor recreation areas of significant value in coastal Louisiana which are being considered as possible additions to the State park system are Isles Dernieres, Little Chenier (in Cameron Parish) and Chenier-au-Tigre (in Vermilion Parish).

The Cheniere region of southwestern Louisiana offers unique outdoor recreation opportunities. However, access by automobile is quite limited in some parts of the region. Little Chenier is an abandoned beach ridge about 5 miles long and up to 50 yards wide. This ridge and Cheniere-au-Tigre, dominated by moss-covered live oaks offer excellent opportunities for camping, picnicking, and sightseeing from a vantage point which provides a close look at the surrounding marshlands.

The Isles Dernieres is a 20 mile long chain of barrier islands in Terrebonne Parish. The topography of these islands consists of sandy beaches, low grassy dunes, and sand flats, salt marsh and mangrove swamp. This environment provides a habitat for a wide variety of birds, most importantly herons and egrets. There is no development on the islands other than a large cabin and docking facility in the Whiskey Island group. There are no roads, trails, or utility services. Oil fields surround the islands but there is no industry activity on the islands. Access is possible only by boat or airplane.

The most popular recreation activity on the Isles Dernieres is sport fishing from the beach or offshore in the surrounding waters. Camping, picnicking, and sightseeing is also done but most often in conjunction with sport fishing. Use of the island for other recreation is limited because of limited access and frequent flooding by storm tides.

A1. Holly Beach	A2. Rutherford
A3. Hackberry	A4. Cypremort
A5. Isles Dernieres	A6. Grand Isle

HISTORICAL AND ARCHEOLOGICAL SITES

Evidence of human habitation for more than 7,000 years has been found in Louisiana. The earliest inhabitants were probably nomadic hunters. Most evidence of their existence (chipped stone spear points) has been found in northwestern Louisiana but some artifacts found near Avery Island may have been made by these early hunters. Numerous archeological sites providing evidence of more recent inhabitants in coastal Louisiana have been identified. These sites have provided a variety of objects such as pottery, stone projectile points, burial mounds, and shell middens which give evidence of the cultural development of the prehistoric inhabitants of the area. Archeologists, having discovered and analyzed this evidence, have divided the time that man has inhabited coastal Louisiana into nine periods (U.S. Army Corps of Engineers, Appendix F, 1973).

Lithic		--	5000 B.C.
Archaic	5000	--	1500 B.C.
Poverty Point	1500	--	100 A.D.
Tchefuncte	400BC	--	500 A.D.
Marksville	100	--	800 A.D.
Troyville	450	--	1200 A.D.
Coles Creek	800	--	1500 A.D.
Plaquamine	1100	--	1500 A.D.
Historic	1500	--	present

These periods indicate the progressive stages in cultural development in coastal Louisiana. The nomadic hunters of the Lithic period represent the lowest stage in cultural development having built no permanent dwellings and having made no use of pottery. Pottery was first made probably in the Tchefuncte period. In the Marksville period there is evidence of cultural influences from new tribes entering the area: more ornate pottery; different burial custons. During the Troyville period bows and arrows and round houses first appear. The transition from nomadic hunting and gathering to sedentary agriculture eventually took place and evidence of an agricultural society is definitely present during the Plaquamine period.

The historic period begins with the first explorations of the Gulf coast by European explorers and continues to the present time. Numerous old forts and other sites important in the history of Louisiana have been restored and preserved.

The following is an inventory of some of the major historical sites in coastal Louisiana, the numbers corresponding to those on the maps (Fig. 37a-g).

1. Big Oak - Little Oak Islands
2. The Cabildo
3. Cable, George Washington House
4. French Market - Old Meat Market
5. French Market - Old Vegetable Market
6. The Garden District
7. Girod Nicholas House
8. Hermann-Grima House
9. Jackson Square
10. Lafayette Cemetery No. 1
11. Lafitte's Blacksmith Shop
12. Lower Garden District
13. Madame John's Legacy
14. Merieult House
15. Old Ursuline Convent
16. Pilot House (Ducayet House)
17. The Presbytere
18. St. Mary's Assumption Church
19. Vieux Carre Historic District
20. Fort Pike
21. Fort de la Boulaye Site
22. Fort Jackson
23. Fort St. Philip
24. Chalmette National Historical Park
25. St. Martin of Tours Catholic Church
26. U.S. Post Office
27. The Shadows-on-the-Teche
28. Homeplace Plantation House
29. Fort Livingston
30. Ellendale Plantation
31. San Francisco Ante-Bellum Home
32. Albania Historical Site
33. Evangeline Oak
34. Munell Home
35. Sabine Pass Lighthouse

The first 28 of the above sites are included in the National Register of Historic Places as of February 1, 1973 as noted in the Federal Register, February 28, 1973.

In addition to those sites listed above and appearing on the maps, there are two additional sites in coastal Louisiana which are in the process of being nominated by the State of Louisiana for inclusion in

the National Register of Historic Places. 1/ These include a site containing eight shell middens in Sabine National Wildife Refuge and a site containing three middens on Lacassine Bayou in the Lacassine National Wildlife Refuge.

Archeological sites on the map (Fig. 44-a-g) are not numbered, however they are coded to indicate the archeological period which they represent. At the scale used, it was impossible to portray the locations of these sites precisely. The purpose of identifying these sites on a map, therefore, is not to pinpoint their exact location but to show in a general way, the distribution and density of known sites of archeological value in the Louisiana coastal area. It is quite possible that there are still undiscovered archeological sites of considerable value in the area.

Natural Landmarks

The National Park Service administers the Natural Landmarks program. The objective of this program is to assist in the preservation of natural areas which will illustrate the diversity of the country's natural history. Registration of a site as a Natural Landmark does not change its ownership. However, the owner of the site is required to preserve the natural character of the registered site in order to retain its registration as a Natural Landmark. Queen Bess Island is presently being considered for inclusion in the National Registry of Natural Landmarks.

1/ Personal communication with Mr. Jay Broussard, Louisiana State Historic Preservation Officer, 1/2/74.

LEGEND: Historical and Archeological Sites

●	Potential Natural Landmark, Queen Bess Island
★	Historical Sites
■	Archeological Sites
Ar	Archaic
Tc	Tchefuncte
Ma	Marksville
Tr	Troyville
Cc	Coles Creek
Pl	Plaquamine

Figure 37-a. --Historical and Archeological Sites

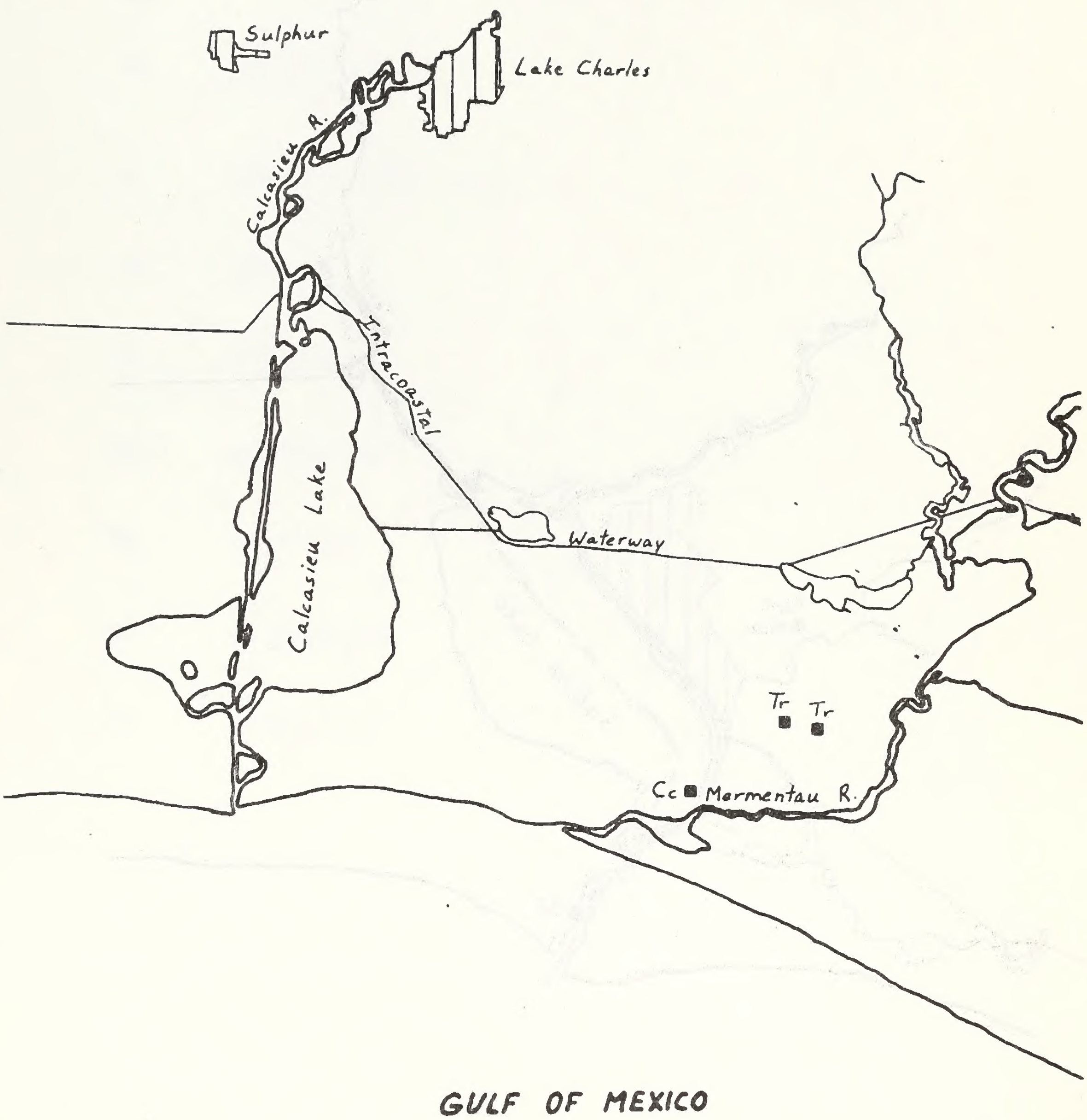

Sulphur
Lake Charles
Calcasieu R.
Intracoastal
Waterway
Calcasieu Lake
Tr
Tr
Cc
Mermentau R.
GULF OF MEXICO

Figure 37-b.

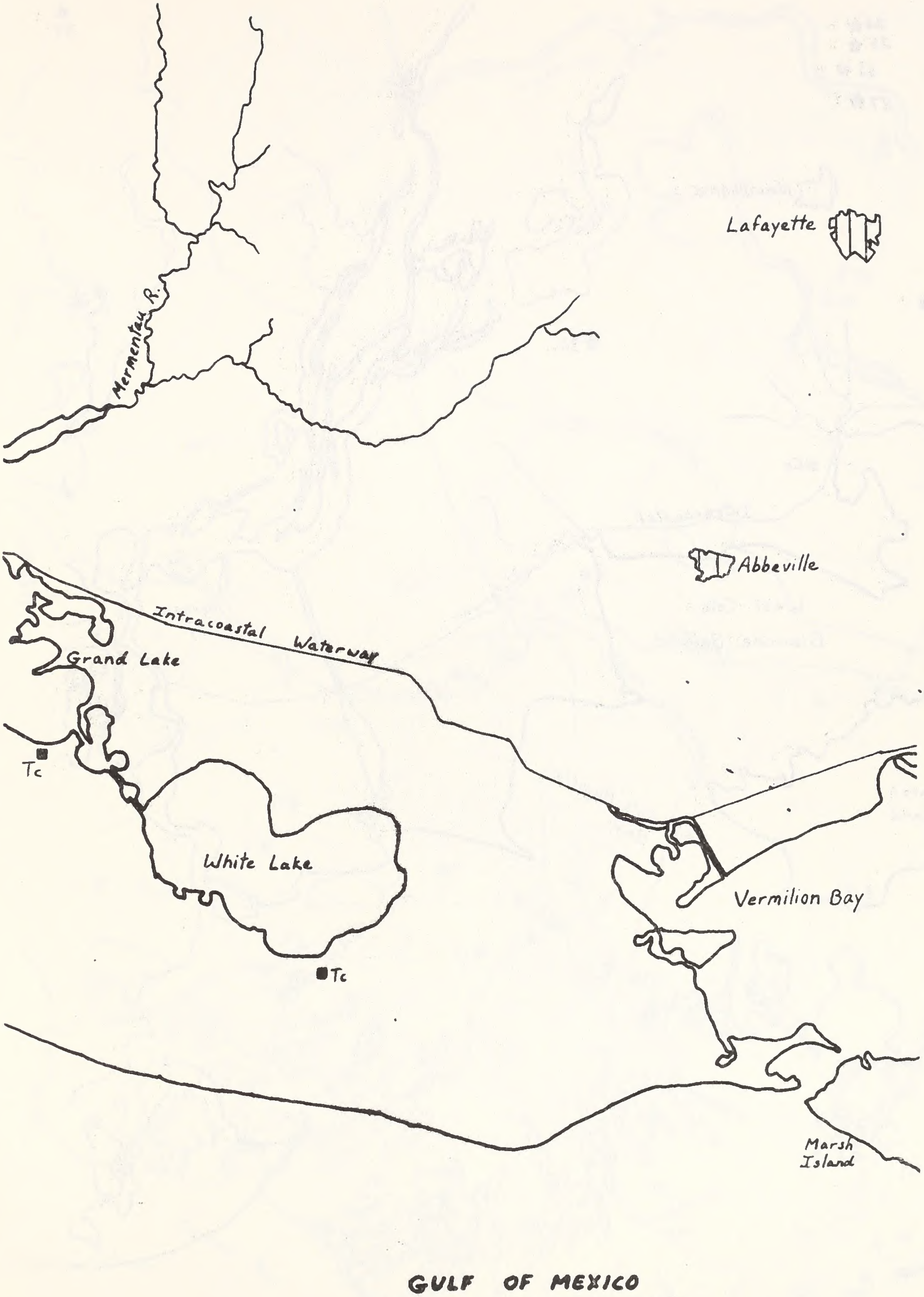

Lafayette
Mermentau R.
Abbeville
Intracoastal Waterway
Grand Lake
Tc
White Lake
Tc
Vermilion Bay
Marsh Island
GULF OF MEXICO

Figure 37-c.

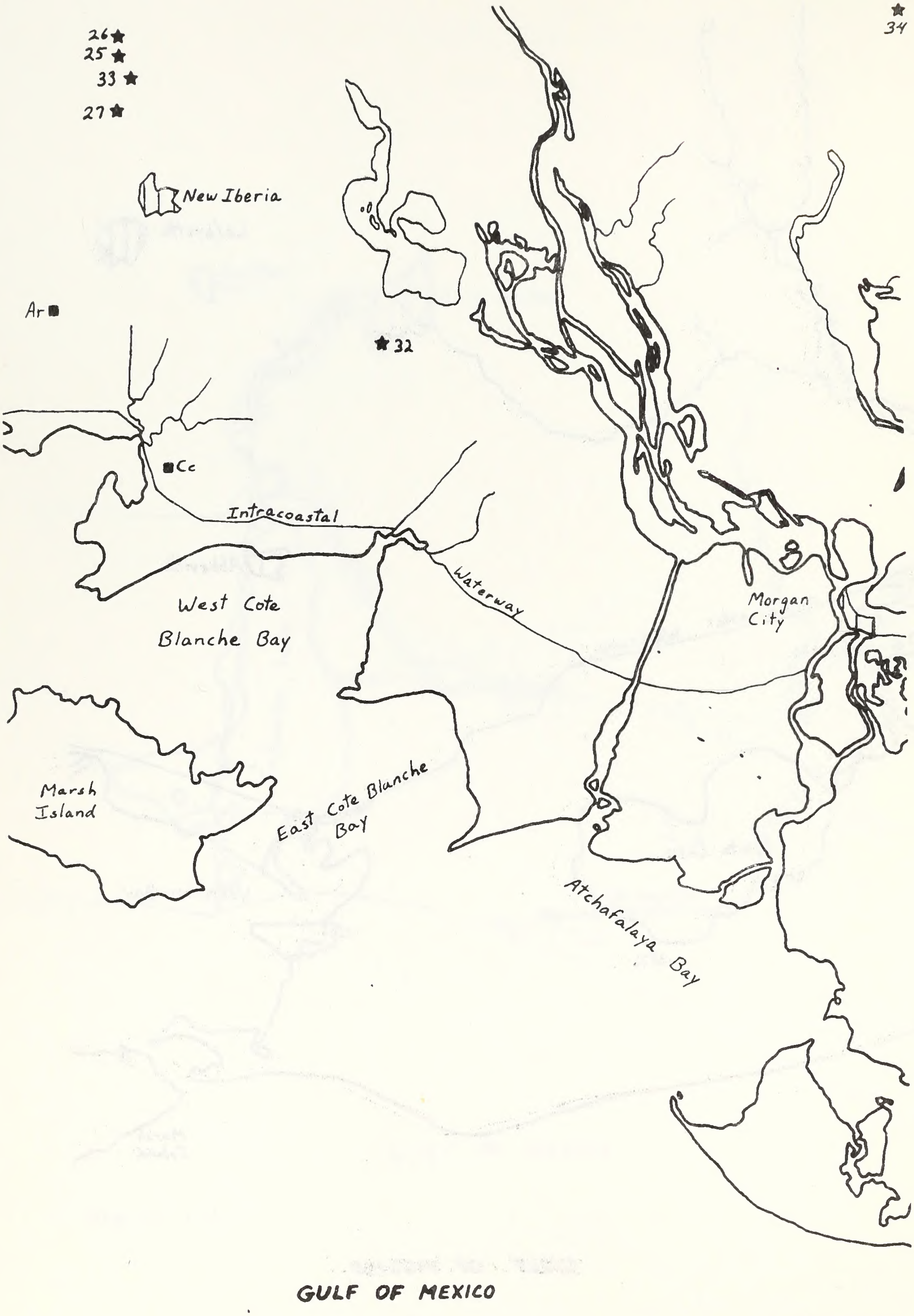
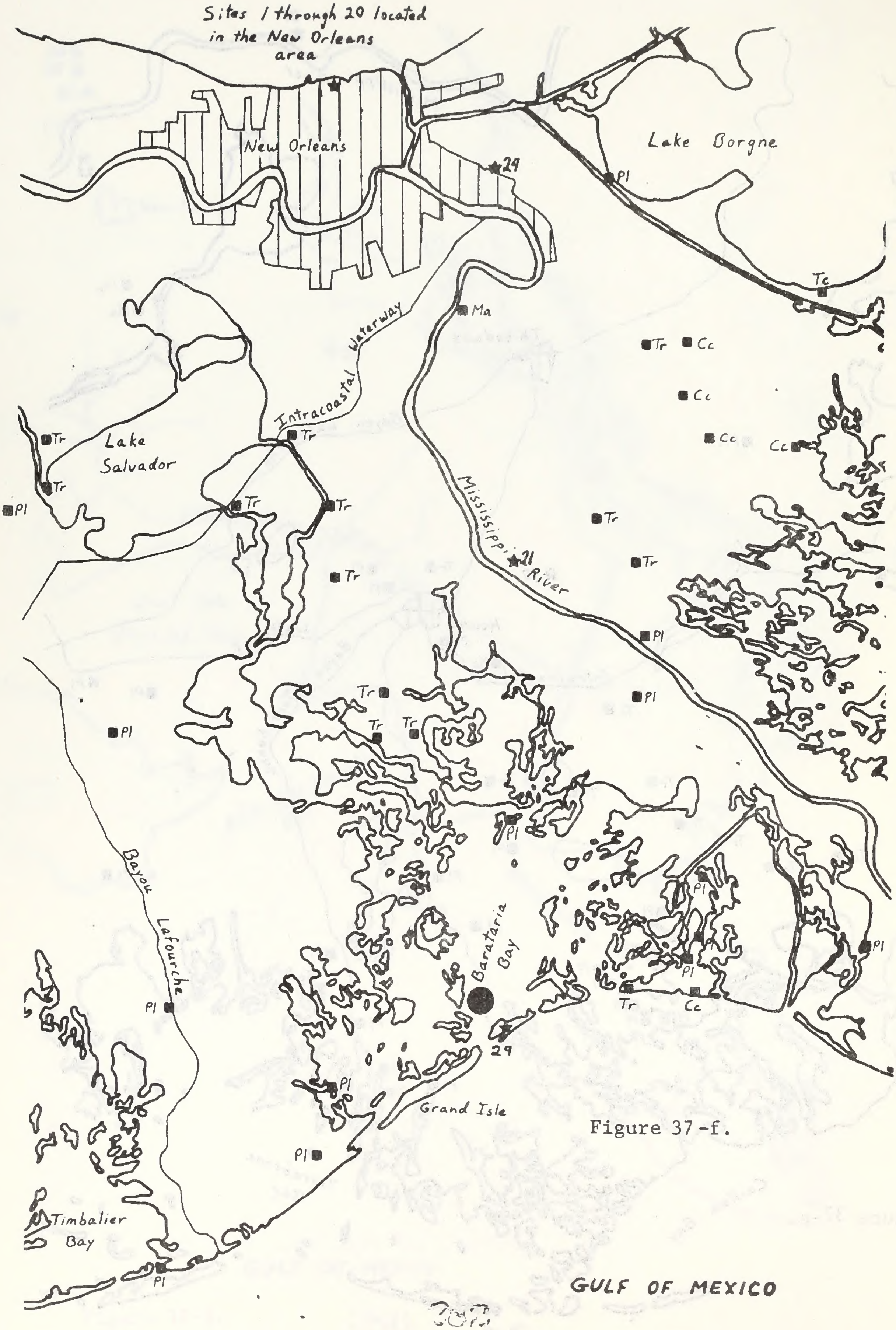

26
25
33
27
34
New Iberia
Ar
32
Cc
Intracoastal
Waterway
West Cote
Blanche Bay
Morgan
City
Marsh
Island
East Cote Blanche
Bay
Atchafalaya Bay
GULF OF MEXICO

Figure 37-d.

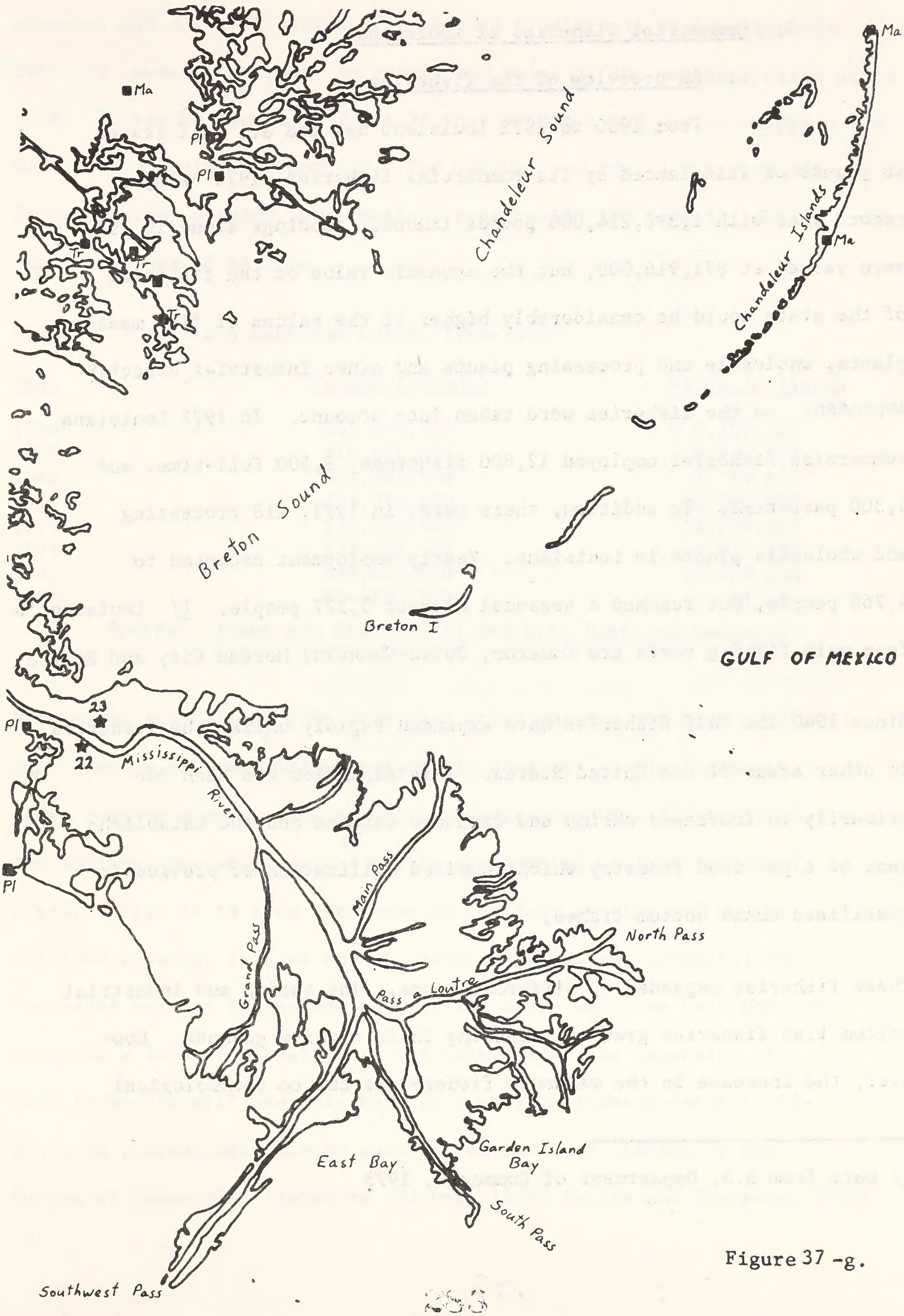

31
Mississippi River
28
Ma
Thibodaux
Bayou Lafourche
Tr
Pl
30
Houma
Waterway
Intracoastal
Bayou Terrebonne
Caillou Bay
Terrebonne Bay

Figure 37-e.



Sites 1 through 20 located in the New Orleans area
New Orleans
Lake Borgne
24
Pl
Tc
Ma
Tr
Cc
Intracoastal Waterway
Lake Salvador
Mississippi River
21
Bayou Lafourche
Barataria Bay
29
Grand Isle
Timbalier Bay
GULF OF MEXICO

Figure 37-f.



Ma
Ma
Pl
Pl
Tr
Tr
Tr
Chandeleur Sound
Chandeleur Islands
Ma
Chandeleur
Breton Sound
Breton I
GULF OF MEXICO
23
22
Pl
Pl
Mississippi River
Main Pass
Grand Pass
North Pass
Pass a Loutre
Garden Island Bay
East Bay
South Pass
Southwest Pass

Figure 37 -g.

3. Commercial Fisheries of Louisiana

a. An overview of the fisheries

From 1950 to 1972 Louisiana has led all Gulf states in pounds of fish landed by its commercial fisheries, 1971 being a record year with 1,396,214,000 pounds landed. Landings alone in 1972 were valued at $71,916,000, but the economic value of the fisheries of the state would be considerably higher if the values of fish meal plants, wholesale and processing plants and other industries directly dependent on the fisheries were taken into account. In 1972 Louisiana commercial fisheries employed 12,800 fishermen, 9,500 full-time, and 3,300 part-time. In addition, there were, in 1971, 218 processing and wholesale plants in Louisiana. Yearly employment amounted to 4,766 people, but reached a seasonal high of 5,577 people. 1/ Louisiana's four main fishing ports are Cameron, Dulac-Chanvin, Morgan City and Empire.

Since 1940 the Gulf fisheries have expanded rapidly unlike the fisheries in other areas of the United States. This expansion has been due primarily to increased shrimp and menhaden catches and the establishment of a pet food industry which required utilization of previously unutilized small bottom fishes.

These fisheries expanded by different means. The shrimp and industrial bottom fish fisheries grew by extending their fishing grounds. However, the increase in the menhaden fishery was due to technological

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1/ Data from U.S. Department of Commerce, 1973

advances and intensification of effort in traditional fishing grounds. Table 32 shows the trends in volume and value of the menhaden catch since 1966. It can be seen from Table 36 that menhaden and shrimp comprise the bulk of the Louisiana landings. The catches and the fishing grounds for most other species have remained essentially the same for this particular period of time.

Table 32. Louisiana Menhaden Catch, 1966-1972

Year	Volume (pounds)	Value (dollars)
1966	555,852,100	$ 9,557,646
1967	510,414,000	6,134,338
1968	622,291,300	7,739,602
1969	856,250,600	12,764,098
1970	959,809,840	18,930,641
1971	1,237,092,700	20,014,923
1972	932,695,610	15,479,920
1973	894,930,390	37,220,673

Source: Jones and Rice (1972) and U.S. Dept. of Commerce (1973e, 1973f 1974)

Historical statistical data show that total catches for many popular Gulf species have maintained reasonably constant levels in recent years despite growing fishing efforts indicating that fisheries in the shallow, nearshore waters may be approaching maximum sustained yield. While it is true that some of the less popular and under-utilized species, such as mullet, have a significant potential for increased harvest in shallow waters, the catch has been held constant owing to a lack of markets. In the main, major new expansion of Gulf fisheries will probably have to come from fishing farther off-shore in increasingly deeper waters. Exploratory fishing by the Bureau of Commercial Fisheries (Wathne, 1959; Bullis and Thompson, 1970)

has shown that commercial quantities of a number of desirable species can be caught along the outer edge of the continental shelf and over the deep gulf. Some of these species are:

depth, fathoms	species	Fishing method
30-50	brown shrimp, porgy, atlantic croaker, butterfish	trawl
shelf beyond 50	hake, wenchman, rattails	trawl
100	yellowedge grouper	longline
150-200	tilefish	longline, trawl
200-300	royal red shrimp	trawl
330-350	swordfish	longline
100-1000+	yellowfin tuna	longline

The following table (Table 33) indicates the volume and value of commercial fish landings in Louisiana in 1972.

Table 33. Louisiana Landings for 1973 (preliminary)
(Data from U.S. Department of Commerce, 1974)

Species	Pounds	Dollars
(Fish)		
Bluefish	285	17
Bowfin	42,317	2,975
Buffalofish	1,380,069	193,258
Cabio	4,845	332
Carp	123,421	4,908
Catfish and Bullheads	4,943,177	1,491,747
Croaker	377,023	43,049
Drum, Black	539,641	44,707
Drum, Red (redfish)	1,179,789	228,404
Flounders (unclassified)	269,077	53,311
Garfish	538,297	60,781
Groupers	8,121	687
Jewfish	5,569	285
King Whiting	283,097	24,604
Menhaden	894,930,390	37,220,673
Mullet	102,546	5,398
Paddlefish or Spoonbill	14,237	1,172
Pompano	13,149	14,284
Sawfish	100	42
Sea Catfish	69,975	7,646
Sea Trout, Grey, Small	1,200	163
Sea Trout, Spotted	2,525,023	774,536
Sea Trout, White	150,815	17,671
Shad	375,000	11,250
Sharks	800	69
Sheepshead, Freshwater	701,409	83,153
Sheepshead, Saltwater	168,503	11,468
Snapper, Red	349,791	142,694
Spanish Mackerel	88,828	7,709
Spot	23,170	1,353
Tripletail	3,006	237
Unclassified for Industrial	124,999	5,938
Total fish	909,337,715	40,457,538
(Shellfish)		
Crabs, Blue, Hard	22,730,157	2,767,023
Crabs, Blue, Soft and Peeler	119,475	131,552

Table 33. (Continued)

Crawfish, Freshwater	10,000,232	1,944,879
Shrimp, Saltwater (heads on)	58,641,288	45,773,389
Oysters (meats)	8,953,779	5,545,022
Turtles, Sea	15,000	4,200
Turtles, Snapper	13,032	3,663
Frogs	29,974	18,261
Total Shellfish	100,502,937	56,187,789
Grand Total	1,009,840,652	96,642,327

For the sake of an orderly presentation, the description of the Louisiana fisheries will be divided into three parts: finfish, shellfish (excluding shrimp), and shrimp. The purpose here is not to treat the biology of the species important to the fisheries since this has been done in previous sections, but to describe the various aspects of the most economically important fisheries.

b. Finfish

Figure 38 illustrates the distribution of finfish catches in Louisiana waters. The finfish catch comprises the bulk of the Louisiana catch and of this, menhaden is by far the most important, as indicated in Table 33. However, the Louisiana landings (Table 33) do not reflect all the menhaden caught in Louisiana waters since catches landed in other states, primarily Texas and Mississippi, are not included.

Although it accounts for the bulk of the finfish catch and for much of the employment in the State's fish processing plants, the menhaden fishery employs only about 10% of Louisiana's fishermen. Menhaden are caught by the purse seine method. A typical menhaden fishing operation involves a carrier vessel of from 100 to 200 feet in length, two small boats to set the purse seine, and often a spotter plane to locate the fish schools. The purse seine, a large net with floats along the top and weights along the bottom is strung out in a circle by the two purse boats, enclosing a school of fish. The bottom of the net is then drawn closed and entraps the fish.

The largest portion of the catch is taken offshore in depths up to 40 meters. Most of the inshore harvest of menhaden is taken in Breton and Chandeleur Sounds since purse seining is prohibited in other inshore waters.

Most of the menhaden catch is processed into fish meal, oil, and fish solubles.

The market for fish meal is steadily increasing due to its popularity as a feed for livestock and poultry. Menhaden is the primary species used in the manufacture of fish meal in this country and there is a market for all that can be caught.

The industrial bottom fish fishery, a relatively new fishery, is now the third largest fishery in the Gulf. The principle species involved in this catch are croaker (56% of the catch), spot, sand seatrout, silver seatrout, in addition to others. (Taylor, et al, 1973).

This fishery is located in shallow waters and is carried on primarily by old shrimp vessels. Fish are taken by otter trawl and are processed into pet food and fish meal. The demand for fish meal makes expansion of this fishery possible if new areas, such as western Louisiana are fished, and if "trash fish" caught with shrimp can be utilized.

As is apparent from Table 33 a wide variety of other fish, though not individually as important as menhaden, contribute substantially to the Louisiana catch.

LEGEND: Areas of Commercial Finfish Harvest

Inshore and Coastline Fishery

Industrial Bottom Fish Fishery

Menhaden Fishery

Reef and Oceanic Fish Fishery

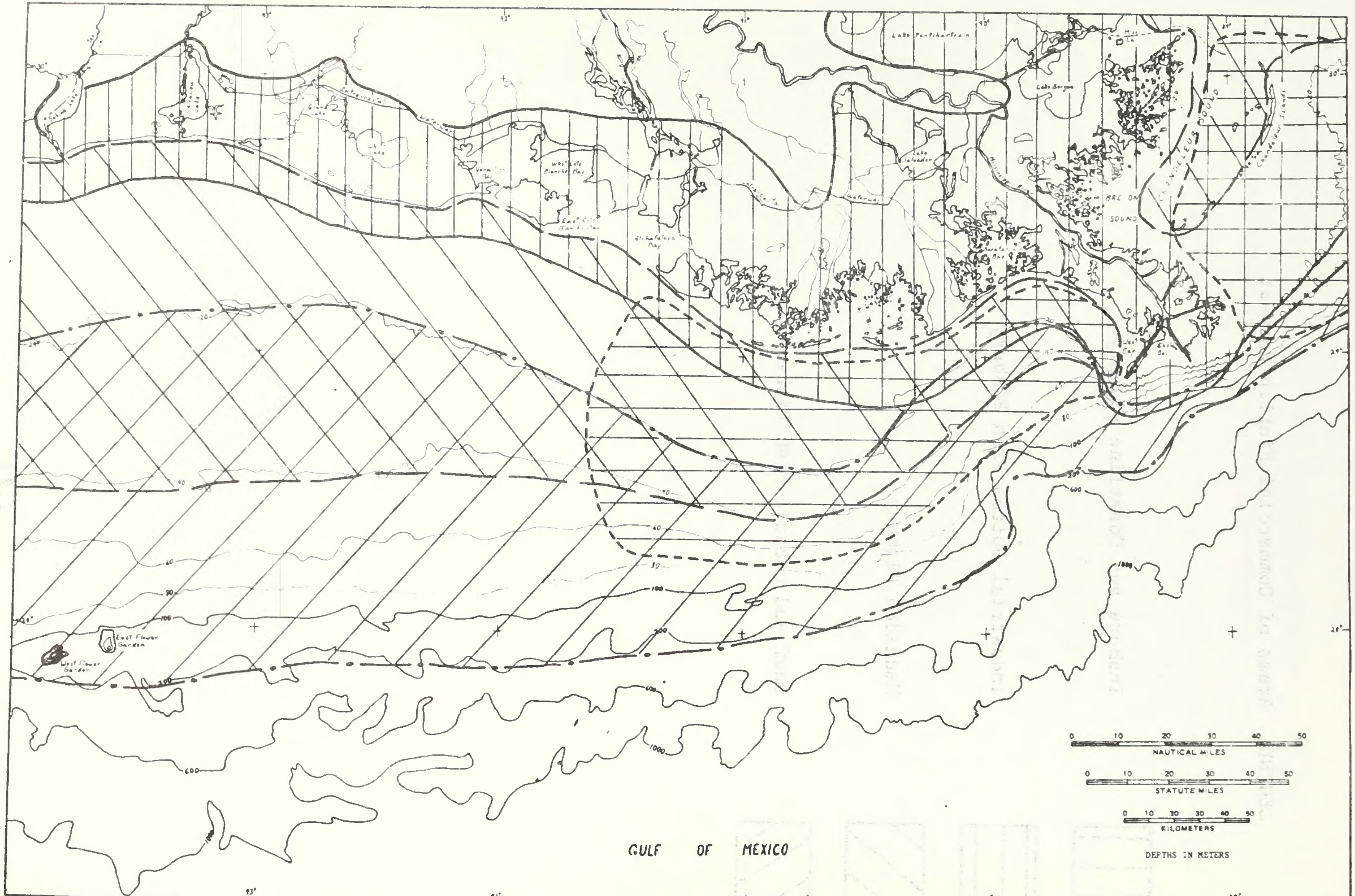

Figure 38. Areas of Commercial Finfish Harvest.

c. Shellfish (excluding shrimp)

Figure 39 illustrates the commercial harvest areas for shellfish in Louisiana waters.

Next to shrimp, oysters are the highest value species of shellfish caught commercially in Louisiana waters (see Table 33) which produce most of the Gulf's catch.

Table 34. Acres of Private and Public Oyster Reefs, Oyster Seed Ground Areas, and "Red Line" areas in Louisiana, 1969

Parish	Private 1/	Public	Oyster Seed Ground Reservation 2/	Red Line Areas 3/
Calcasieu		1,200		
Iberia	701			
Jefferson	10,759		4,015 4/	
Lafourche	7,955			
Orleans	333			
Plaquemines	37,654		2,666 5/	
St. Bernard	36,939			
St. Mary	713			
St. Tammany	208			
Terrebonne	20,347		9,772	
Vermilion	709			
Total	116,318	1,200	16,453	450,000

1/ Leased from State

2/ Areas managed by the state, with open and closed seasons for the taking of seed oysters.

3/ Areas of natural seed grounds in the parishes of Plaquemines and St. Bernard which have some remaining slow productive reefs and in which production of seed oysters is increased periodically by the planting of clam shell.

4/ Part of the area is in Lafourche Parish.

5/ Part of the area is in St. Bernard Parish.

Data from Perret, et al, 1971

LEGEND: Areas of Commercial Shellfish Harvest

Crawfish

Blue Crabs

Turtles

Oysters

Rangia

Natural Oyster Reefs

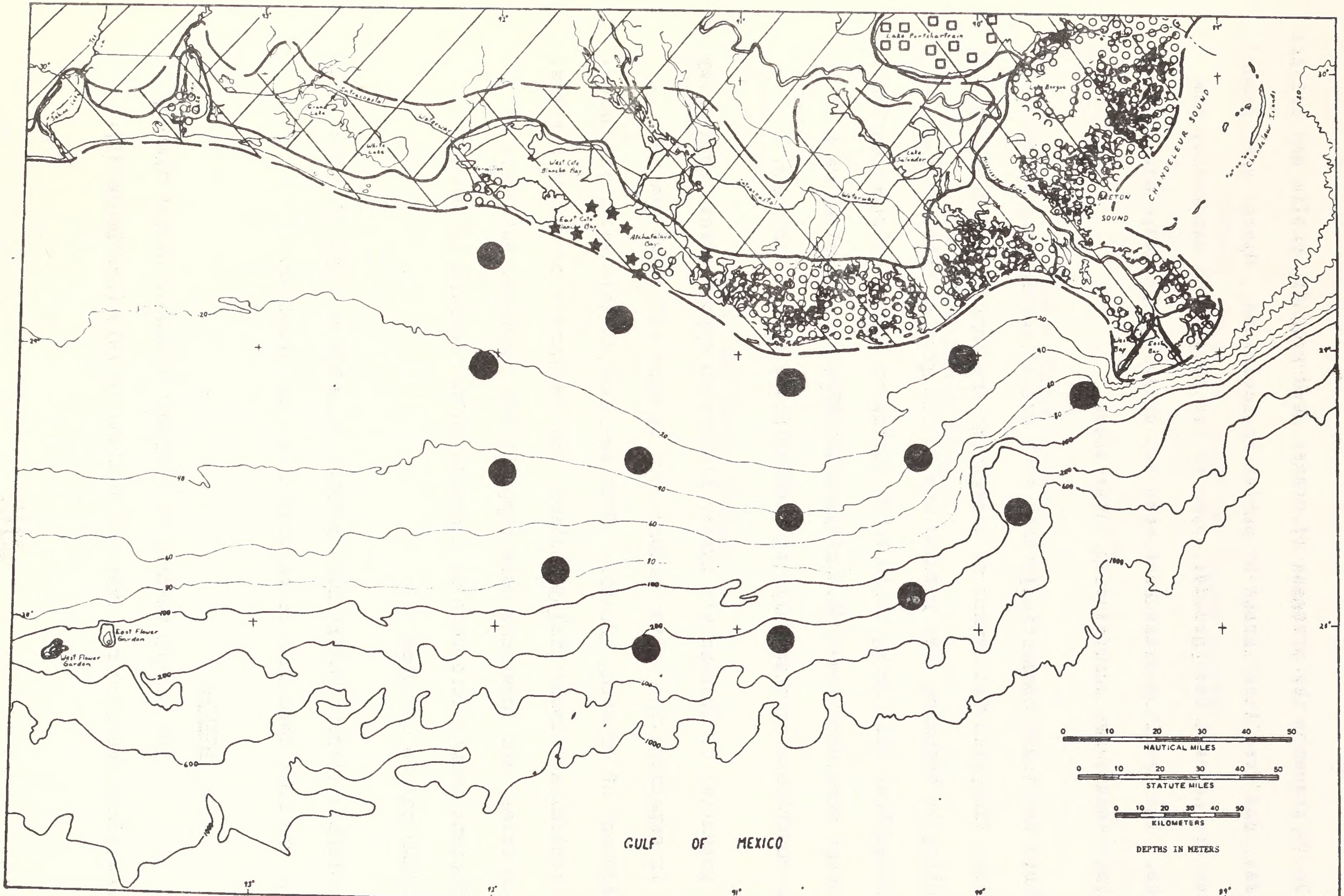

Figure 39. Areas of Commercial Shellfish Harvest.

Table 34 presents the acreages of oyster seed grounds, public and private leases, and "red line" areas by parish in Louisiana. Oyster seed ground areas are natural seed grounds, open to the public but managed by the State. The red line areas have been set aside by the State and no new private leases are permitted in these areas.

Oysters are taken commercially from both public acreage and private leases. The principle means of harvesting are tonging and dredging. Dredging is becoming more popular due to its greater efficiency. A dredge boat will bring in 10 to 50 barrels a day. Louisiana oyster landings were worth over $4.4 million in 1972, but Louisiana waters also contribute substantially to Mississippi's oyster landings.

The potential of Louisiana's oyster fishery to expand exists apparently not in expanding the oyster grounds but in more efficient use and management of existing grounds. Problems such as salt water intrusion, residential and industrial pollution, and inaccurate counts of catches, catch rates, and locations have hampered the industry, but there is sufficient demand to absorb an increase in the harvest if these problems can be overcome.

Louisiana's inshore waters also provide valuable catches of other shellfish, the most important being blue crabs and crawfish.

d. Shrimp

The shrimp fishery is the most valuable single fishery of Louisiana, being worth over $45 million in 1973 (see Table 35).

LEGEND: Areas of Commercial Shrimp Harvest

White Shrimp Fishery

Pink Shrimp Fishery

Brown Shrimp Fishery

Royal Red Shrimp Fishery

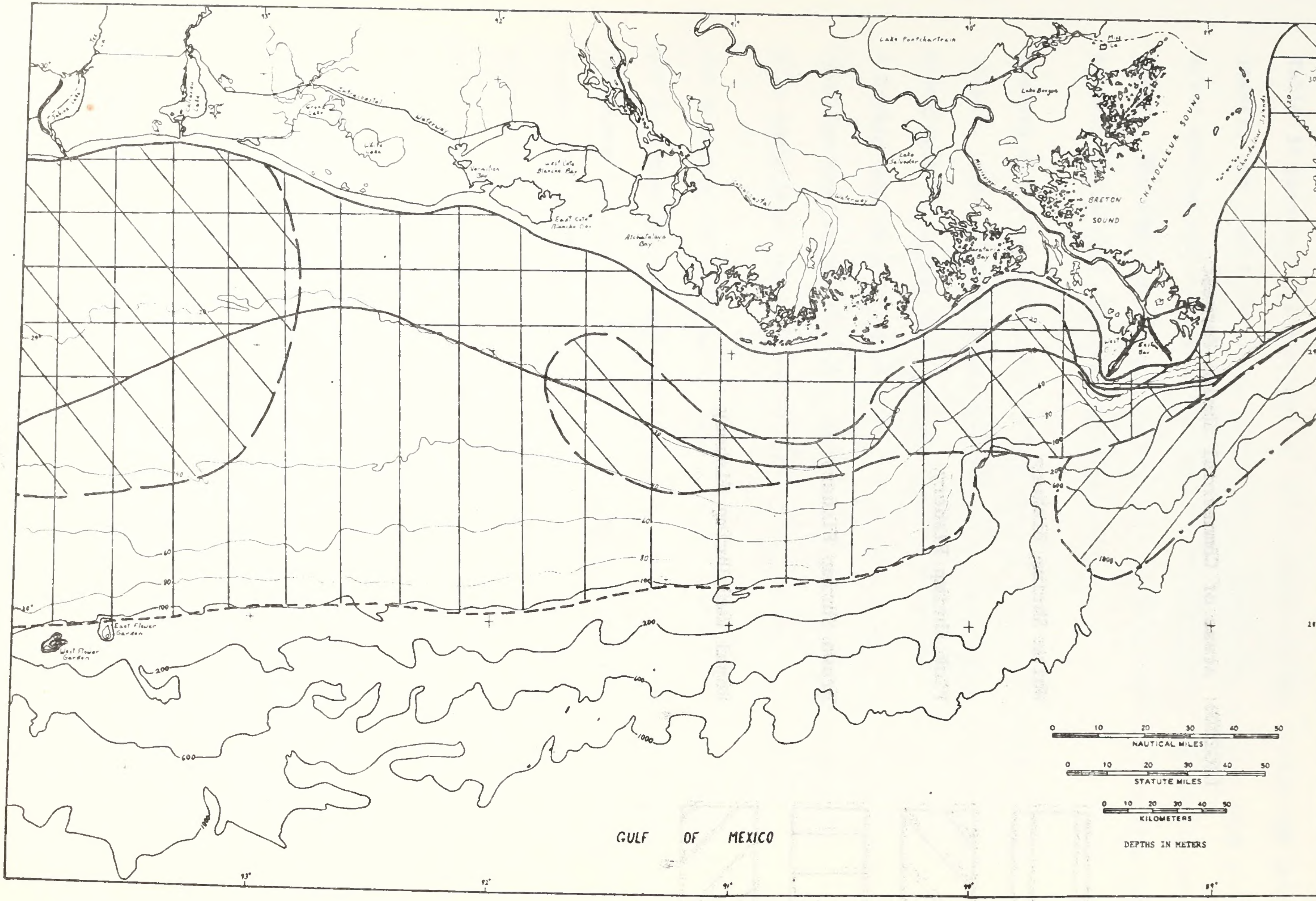

Figure 40. Areas of Commercial Shrimp Harvest.

Table 35. Louisiana Shrimp Catch, 1966-1972
Pounds, Value, and Percentage of Total Catch

Year	Pounds (Heads-on)	Dollars	Percentage of Total Catch, By Dollar Value
1966	62,284,100	$24,391,715	61.4
1967	75,328,700	24,576,130	64.9
1968	67,769,000	25,623,000	58.7
1969	82,889,100	33,358,828	59.4
1970	90,725,170	34,584,288	56.6
1971	92,475,421	43,283,908	59.0
1972	82,987,746	47,020,975	64.6
1973	58,641,288	45,773,389	47.4

Source: Jones and Rice (1972) and U.S. Dept. of Commerce (1973e, 1973f, 1974)

Not only do Louisiana's landings account for a large percentage of the Gulf catch, but Louisiana waters supply part of other states landings, and the vast marshlands of coastal Louisiana provide a valuable nursery area for the shrimp populations of the Gulf. The Louisiana shrimp catch is composed primarily of brown shrimp and white shrimp with lesser amounts of royal reds and pink shrimp.

The commercial shrimp fleet is highly modernized and efficient. Most of Louisiana's commercial fishermen are employed in the shrimp fishery. Shrimp are caught by otter trawls, most larger vessels now having two trawls, and vessels may travel considerable distances to where the shrimp are seasonally abundant. Brown shrimp are caught at night and the season is generally from May to October. White shrimp are usually caught during the day, the most productive season being in the fall. The royal red fishery is relatively new and occurs in deeper waters than the brown and white shrimp fishery.

There is presently a good market for shrimp and it has been increasing for many years. In fact domestic fisheries cannot meet the demand. Since existing stocks of shrimp are presently being fully utilized, increased production will depend on the utilization of as yet undiscovered stocks or currently un-utilized species, and on successful aquaculture ventures.

4. Ports and Shipping

The ports and harbors along the Gulf Coast from Mobile to Houston are shown in Table 36. The major ports in Alabama, Mississippi, and Texas are included to show the magnitude of water borne traffic over the entire area. Of the more than 345 million tons of freight that passed through the nine ports and harbors of Table 36, 54% was handled by the three Louisiana harbors.

Of the 438.5 million tons of freight handled through all gulf ports in 1971, 178.5 million tons or almost 41% was crude oil and petroleum products. Also, of these same 438.5 million tons of freight, 112.2 million tons, or a bit more than 25% moved in foreign trade (imports plus exports) and of this foreign trade only 10.9 million tons (8.6 million tons imports plus 2.3 million tons exports) or less than 10% was crude oil and petroleum products.

Table 36. Major Ports and Harbors
U.S. Gulf Coast - Year 1972 1/

Harbor	Maxi, Depth (Feet)	Freight Traffic (Short Tons x 1000) Total	Petroleum 2/	Vessels (Inbound) Total	Tankers & Tank Barges3/
Mobile, Ala.	42.0-38.0	27,291	5,936	13,714	1,916
Pascagoula, Miss.	40.0-38.0	12,435	6,430	10,062	2,798
Gulfport, Miss.	31.0-27.5	1,198	53	702	59
Lake Charles, La.	33.0	17,029	11,883	16,901	5,895
Baton Rouge, La.	40.0	52,903	14,211	20,700	8,365
New Orleans, La.	40.0-36.0	125,719	42,237	75,830	18,953
Port Arthur, Tex.	40.0	21,708	18,846	8,313	3,715
Beaumont, Tex.	36.0	32,391	23,101	11,583	5,922
Houston, Tex.	39.0	7,431	33,757	33,501	11,463
Texas City, Tex.	40.0	20,355	17,026	9,209	6,505
Galveston, Tex.	41.0	54,567	92	5,625	1,702
Total 11 Ports		437,027	173,572	206,140	67,293

1/ Waterborne Commerce of the United States - Calendar Year 1972 Part 2 Waterways and Harbors Gulf Coast, Mississippi River System and Antilles - Department of the Army, Corps of Engineers.

2/ Includes crude oil, gasoline, jet fuel, kerosene, distillate fuel oil, residual fuel oil, lubricating oil and greases, and LPG.

3/ Somewhat understated as this column includes only tanker and tank-barges and no tugs or towboats which are included in the preceding column.

5. <u>Economy of the Coastal Zone</u>

For purposes of a socio-economic description, the Louisiana OCS No. 36 Sale region will be discussed in terms of economic areas delineated by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. The region corresponds approximately to BEA Economic Areas 137, 138, 139, 140. For each of these areas, two tables, reproduced from the OBERS report 1/ (see Appendix G) show historic and projected population, employment, and earnings. This volume is largely based on 1970 census data. These projections provide an outline of regional economic growth based on historical trends. Thus, they may be interpreted as a baseline delineation of socio-economic conditions against which the impacts of an isolated factor may be compared.

The direct impact of Louisiana OCS No. 36 sale will be on the State Louisiana and therefore only BEA areas 138 and 139 which include the entire coastal area of Louisiana will be examined in detail.

1/ For additional information see Area Economic Study, Report on Gulf Coast Deep Water Port Facilities Texas, Louisiana, Mississippi, Alabama, and Florida. Appendix C. Army Corps of Engineers, 1973.

BEA ECONOMIC AREA 138--NEW ORLEANS, LOUISIANA

BEA Economic Area 138 is located in southeastern Louisiana and southwestern Mississippi. It is composed of 23 Louisiana parishes and 13 Mississippi Counties, which had a land area of 19,959 square miles in 1970. The Louisiana parishes are: Ascension, Assumption, Concordia, East Baton Rouge, East Feliciana, Iberville, Jefferson, Lafourche, Livingston, Orleans, Plaquemines, Pointe Coupee, St. Bernard, St. Charles, St. Helena, St. James, St. John the Baptist, St. Tammany, Tagipahoa, Terrebonne, Washington, West Baton Rouge, and West Feliciana. The counties in Mississippi are: Adams, Amite, Franklin, Hancock, Jefferson Davis, Lawrence, Lincoln, Marion, Pearl River, Pike, Walthall, and Wilkinson.

Some social characteristics are population, population density, population mobility, and housing tenure.

Population in BEA Economic Area 138 was 2.1 million in 1970 according to the 1970 Census of Population (Table 37). This is an increase of 14.0 percent from 1960, compared with a 13.3 percent increase for the United States. Projections are that the population will reach 4 million by 2020, for an average annual rate of growth of 1.26%, compared with 1.36% for the U.S. as a whole. A major part of the increased population occurred in East Baton Rouge, Jefferson, St. Bernard, and St. John the Baptist Parishes, Louisiana.

Table 37

SELECTED ECONOMIC INDICATORS, 1970-2020
BEA ECONOMIC AREA 138

ECONOMIC INDICATOR 1/	1970	1980	1990	2000	2010	2020
Population	2,148,601	2,460,700	2,804,500	3,153,000	3,558,700	4,012,700
Personal Income	6,310,927	10,013,400	15,013,600	23,028,100	34,606,200	51,690,000
Value Added by Manufacture	2,192,791	3,347,346	5,024,008	7,741,078	11,757,629	17,730,035
Value of Farm Products Sold	174,649	209,543	237,987	284,271	369,771	492,467
Value of Mineral Production	2,781,335	3,560,331	4,408,808	5,517,984	6,718,550	8,184,625

1/Income and Values in thousands of 1967 Dollars

SOURCES: OBERS
Census of Population, 1970
Census of Manufactures, 1963, 1967
Census of Agriculture, 1964, 1969
Bureau of Mines Minerals Yearbook, 1970

Population Density--Population per square mile in BEA Economic Area 138 was 108 persons in 1970, an increase of about 41 percent from its 1950 density of 76 persons per square mile. The four most densely populated state division were Orleans, St. Bernard, Jefferson, and East Baton Rouge, parishes in Louisiana, with population densities of 3,013, 995, 915, and 621 persons per square mile, respectively. These four parishes were components of the economic areas two Standard Metropolitan Statistical Areas (SMSA's). East Baton Rouge Parish is the Baton Rouge, Louisiana SMSA; Orleans, St. Bernard, Jefferson Parishes are joined with St. Tammany Parish to form the New Orleans, SMSA. The four most densely populated parishes accounted for almost 59 percent of the economic area's population in 1970. The remaining counties and parishes had population densities which were less than the average of the economic area of 108 persons per square mile.

Population Mobility--Data on population mobility were available for the Baton Rouge and New Orleans SMSA's of BEA Economic Area 138 from the 1970 Census of Population. Based on these data, nearly 25 percent had lived in the present house less than two years, and almost 56 percent had lived in the present house five years or less.

Housing Tenure--According to the 1970 Census of Population and Housing, about 50 percent of total housing in the Baton Rouge and New Orleans SMSA's was owner occupied, 42 percent was renter occupied, and 8 percent was vacant.

Both population mobility and housing tenure are significant indications of the social stability of an area.

Some significant economic indicators are Personal Income, Value added by Manufacture, Value of Farm Products sold, Value of Mineral Production, and employment. Taken together these can be used to determine both the size, importance and type (agricultural, industrial etc.) an economy.

Total employment in 1970 for BEA Economic Area 138 was 713,159 according to the 1970 Census of Population (Table 38). Wholesale and retail trade comprised 20.9 percent of total employment; professional services, 18.1 percent; manufacturing, 15.2 percent; and business services, 10.6 percent.

From 1970 to 2020 the economic area's total employment will increase at an average annual rate of 1.56 percent according to OBERS projections. Employment growth rates in professional services and manufacturing are expected to exceed that of total employment and account for 24.7 percent and 16.4 percent of the total in 2020, respectively. Wholesale and retail trade and business services are expected to have employment growth rates slower than the total with their relative shares declining to 19.0 and 7.8 percent, respectively.

Table 38

EMPLOYMENT FOR SELECTED INDUSTRIES, 1970-2020
BEA ECONOMIC AREA 138

	1970	1980	1990	2000	2010	2020
Agriculture, etc.	20,187	23,000	20,100	18,600	18,400	18,400
Mining	23,247	24,000	24,400	24,700	24,900	24,900
Contract Construction	60,041	83,600	93,200	106,100	118,600	131,400
Manufacturing						
Food & Kindred	14,822	20,100	19,300	18,600	18,000	17,500
Textiles & Pr	10,319	10,000	10,400	10,800	11,100	11,500
Printing & Publ	5,015	7,500	8,700	10,300	12,100	14,100
Chemicals & Allied Pr	18,487	22,500	30,700	41,600	54,400	69,200
Lumber Prod & Furn	8,974	8,400	8,200	8,100	7,900	7,800
Machinery, All	5,108	9,600	11,500	14,000	16,600	19,400
Transportation Equip	14,467	20,500	25,200	31,300	37,700	44,700
Paper & Allied Pr	9,258	10,900	12,400	14,500	16,600	18,900
Petroleum & Related	9,032	9,526	10,240	10,954	11,688	12,383
Metal Industries	13,038	18,600	22,200	27,000	32,200	37,900
Railroad Transportation	5,442	5,900	5,300	4,800	4,300	3,800
Trucking & Warehousing	8,523	11,800	13,700	16,200	18,700	21,300
Other Transportation	24,869	42,600	46,400	51,700	56,600	61,600
Communications	9,412	10,600	12,400	14,700	17,000	19,500
Utilities	15,346	11,800	13,200	15,100	16,900	18,800
Wholesale & Retail Trade	149,339	173,100	196,300	227,600	259,600	293,100
Finance, Ins., & Real Estate	33,185	40,600	46,900	54,900	63,000	71,400
Business Services, etc.	75,327	94,200	98,400	105,800	113,200	121,300
Professional Services, etc.	128,891	163,700	208,000	263,100	321,200	382,200
Civilian Government	33,963	52,000	61,600	74,600	88,700	104,500
Armed Forces	3,257	2,400	2,400	2,400	2,400	2,400
Total 1/	713,159	888,500	1,014,100	1,181,900	1,358,100	1,546,000

1/ Includes industries not listed.
SOURCES: 1970 Census of Population
OBERS

Projections of personal income were taken from the OBERS report (Table 37). Data for 1970 were derived by interpolation of OBERS figures. The average annual rate of growth for BEA Economic Area 138 from 1970 to 2020 is 4.34 percent, compared with 4.24 percent for the United States. Personal income indudes earnings and unearned income such as dividends, rents and transfer payments.

Earnings in BEA Economic Area 138 totaled $5.0 billion in 1967 dollars for 1970 (Table 39). Earnings from manufacturing ranked first, accounting for 20.2 percent of the total. Other leaders in earnings were wholesale and retail trade, 18.3 percent; services, 15.0 percent; and government, 14.1 percent. Mining accounted for 5.78%. Comparable U.S. figures 29.1, 16.4, 14.7, 16.9, and 1.0 percents.

According to the OBERS report, earnings for the economic area will total $39.3 billion in 1967 dollars by 2020, an average annual increase from 1970 of 4.21 percent. Average annual rates of growth for the leading industries are: manufacturing, 4.07 percent; wholesale and retail trade, 4.22 percent; services 4.76 percent; and government, 4.94 percent.

Value added by manufacture for BEA Economic Area 138 in 1970 was $2.19 billion in 1967 dollars. The projected 2020 value is $17.73 billion in 1967 dollars, an average annual rate of growth of 4.27 percent. The average annual rate of growth for the United States from 1970 to 2020 is 3.93 percent.

Table 39

EARNINGS BY MAJOR INDUSTRY, 1970-2020
BEA ECONOMIC AREA 138
(Thousand 1967 Dollars)

INDUSTRY	1970	1980	1990	2000	2010	2020
Agriculture	$ 103,768	$ 124,500	$ 141,400	$ 168,900	$ 219,700	$ 292,600
Mining	289,184	370,100	458,300	573,600	698,400	850,800
Contract Construction	447,843	659,500	950,000	1,403,800	2,038,400	2,941,800
Manufacturing	1,007,075	1,523,000	2,223,600	3,347,000	4,974,900	7,403,600
Transportation, Etc.	516,099	743,600	1,045,500	1,515,400	2,167,800	3,105,500
Wholesale & Retail Trade	916,750	1,453,400	2,154,600	3,278,100	4,891,000	7,252,600
Finance, Ins. & Real Estate	261,953	407,000	598,400	900,900	1,331,600	1,961,700
Services	748,112	1,278,000	2,019,100	3,227,900	5,004,700	7,642,600
Government	706,623	1,274,100	2,053,900	3,310,500	5,136,500	7,857,000
Total	$ 4,997,407	$ 7,833 200	$11,644,800	$17,726,100	$26,463,000	$39,308,200

SOURCE: OBERS

Value of farm products sold for BEA Economic Area 138 in 1970 was \$174.6 million in 1967 dollars (Table 37) and is projected to be \$492.5 million in 1967 dollars by 2020. The average annual rate of growth from 1970 to 2020 is 2.09 percent, compared with the United States rate of 1.29 percent.

The 1970 mineral production values were taken from the Bureau of Mines Minerals Yearbook for 1970. The total value of mineral production for BEA Economic Area 138 in 1970 was \$2.78 billion in 1967 dollars (Table 37). Minerals included in this figure were: natural gas, natural gas liquids, petroleum, sand and gravel, salt, sulfur, cement, lime, shell, and clays.

The 2020 value of mineral production is projected to be \$8.18 billion in 1967 dollars. This reflects an average annual growth rate of 2.18 percent.

During 1970, eight petroleum refineries were operating in BEA Economic Area 138 with a capacity of 945,300 barrels per calendar day. Annual crude oil input for 1970 was 327.8 million barrels Employment derived from crude oil input totaled 9,032, for an average annual input of 36,300 barrels of crude oil per employee.

Projections of crude oil input in BEA Economic Area 138 are based on OBERS projected petroleum refining indices of output for Water Resource Subarea 809--Mississippi Delta.

Employment projections are based on growth factors of total petroleum and related employment for BEA Economic Areas 38, 137, 139, 140, 141, 142, and 143. Using these factors, employment in the area was projected to increase 37 percent from 1970 to 2020. The OBERS projections for BEA Economic Area 138 indicated a decrease of 9 percent from 1970 to 2020, which was not consistent with the projected crude oil input.

Using the projections of crude oil and employment, total annual crude oil input per employee will increase from 36,000 barrels in 1970 to 114,400 barrels in 2020.

BEA ECONOMIC AREA 139--LAKE CHARLEE, LOUISIANA

BEA Economic Area 139 is located in southern Louisiana and had a land area of 12,211 square miles in 1970. It contains the following parishes: Acadia, Allen, Beauregard, Calcasieu, Cameron, Evangeline, Iberia, Jefferson Davis, Lafayette, St. Landry, St. Martin, St. Mary, Vermilion and Vernon.

Population in BEA Economic Area 139 was 748 thousand in 1970 according to the 1970 Census of Population (Table 40). This is an increase of 14.1 percent from 1960, compared with a 13.3 percent increase for the United States. A major part of the increases population occurred in Lafayette, St. Mary, and Vernon parishes.

Data for population projections were taken from the OBERS report. Average annual rate of growth for the area from 1970 to 2020 was projected to be .66 percent, compared with 1.36 percent for the United States.

Population Density--Population per square mile in BEA Economic Area 139 was 61 persons in 1970, an increase of almost 41 percent from its 1950 population density of 44 persons per square mile.

Population Mobility--Data on pupulation mobility were available for the Lafayette and Lake Charles SMSA's from the 1970 Census of Population. Based on these data nearly 24 percent had lived in the present house less than two years, and nearly 52 percent had lived in the present house five years or less.

TABLE 40

SELECTED ECONOMIC INDICATORS, 1970-2020
BEA ECONOMIC AREA 139

ECONOMIC INDICATOR 1/	1970	1980	1990	2000	2010	2020
Population	748,433	787,400	834,400	890,500	959,900	1,041,000
Personal Income	1,826,230	2,646,000	3,740,300	5,451,100	7,903,700	11,518,100
Value Added by Manufacture	410,065	600,925	874,672	1,309,411	1,936,032	2,859,679
Value of Farm Products Sold	157,630	197,076	212,050	251,819	328,621	440,683
Value of Mineral Production	1,475,748	1,900,173	2,366,914	2,972,018	3,623,244	4,406,376

1/Income and Values in thousands of 1967 Dollars

SOURCES: OBERS
Census of Population, 1970
Census of Manufactures, 1963, 1967
Census of Agriculture, 1964, 1969
Bureau of Mines Minerals Yearbook, 1970

Housing Tenure--According to the 1970 Census of Population and Housing, about 65 percent of total housing in the Lafayette and Lake Charles SMSA's was occupied by the owners, 28 percent by renters, and 7 percent was vacant. Housing Tenure and Population Mobility are indicators of social stability.

The following economic indications, when taken together can form the foundation for a baseline interpretation of the regional economy.

Total employment in 1970 for BEA Economic Area 139 was 243,288 according to the 1970 Census of Population (Table 41). Wholesale and retail trade comprised 19.3 percent of total employment; professional services, 14.4 percent; armed forces, 10.8, and manufacturing 9.9 percent.

From 1970 to 2020 the economic area's total employment will increase at an average annual rate of .92 percent according to OBERS projections. Employment in professional services is expected to increase at a significantly more rapid rate than total employment so that it will account for 21.3 percent of the total in 2020. Employment in manufacturing will also increase at a more rapid rate than the total and account for 12.2 percent of 2020 total employment. Growth rates for employment in wholesale and retail trade and armed forces will be slower than the total's with their relative shares declining to 17.3 and 7.7 percent of the 2020 total, respectively.

Table 41

EMPLOYMENT FOR SELECTED INDUSTRIES, 1970-2020
BEA ECONOMIC AREA 139

	1970	1980	1990	2000	2010	2020
Agriculture, etc.	15,315	14,700	12,500	11,400	11,200	11,300
Mining	17,455	16,100	15,800	15,600	15,300	15,000
Contract Construction	20,573	19,600	20,800	22,800	24,800	27,000
Manufacturing						
Food & Kindred	4,479	5,300	4,900	4,500	4,200	4,000
Textiles & Pr	588	300	300	400	500	500
Printing & Publ	1,210	1,700	1,800	2,000	2,200	2,400
Chemicals & Allied Pr	5,122	7,300	8,500	10,100	11,700	13,300
Lumber Prod & Furn	2,093	2,200	2,100	2,100	2,000	2,000
Machinery, All	1,227	2,300	2,800	3,500	4,200	5,100
Transportation Equip	2,200	3,500	3,900	4,500	5,100	5,700
Paper & Allied Pr	1,024	1,200	1,400	1,700	2,000	2,300
Petroleum & Related	4,846	5,500	6,200	6,800	7,500	8,200
Metal Industries	1,352	1,400	1,800	2,300	2,800	3,400
Railroad Transportation	1,388	1,100	900	800	700	600
Trucking & Warehousing	2,195	2,300	2,600	3,000	3,400	3,800
Other Transportation	5,360	11,200	13,300	16,000	18,800	21,800
Communications	2,536	2,800	3,000	3,400	3,800	4,300
Utilities	4,790	6,500	7,300	8,500	9,800	11,100
Wholesale & Retail Trade	47,066	49,400	52,000	56,400	61,100	66,500
Finance, Ins., & Real Estate	7,167	6,800	7,600	8,700	9,900	11,200
Business Services, etc.	23,227	30,100	28,800	28,700	29,000	29,800
Professional Services, etc.	34,987	42,700	50,400	60,200	70,500	81,600
Civilian Government	8,868	10,500	12,100	14,300	16,800	19,700
Armed Forces	26,395	29,400	29,400	29,400	29,400	29,400
Total 1/	243,288	276,400	293,200	320,200	350,400	384,000

1/ Includes industries not listed.
SOURCES: 1970 Census of Population
OBERS

The average annual rate of growth for BEA Economic Area 139 from 1970 to 2020 is 3.75 percent compared with 4.24 percent for the United States.

Earnings in BEA Economic Area 139 totaled $1.44 billion in 1967 dollars for 1970 (Table 42). Earnings from government ranked first, accounting for 24.2 percent of the total. Other leaders in earnings were wholesale and retail trade, 15.1 percent; manufacturing, 13.6 percent; services, 11.2 percent; and mining 11.08%. United States Figures are 16.9, 16.4, 29.1, 14.7, and 1.0% respectively.

According to the OBERS report earnings for the economic area will total $8.76 billion in 1967 dollars by 2020, an average annual increase from 1970 of 3.67 percent. Average annual rates of growth for the leading industries are: government, 3.79 percent; wholesale and retail trade, 3.85 percent; manufacturing, 3.75 percent, and services, 4.40 percent.

Value added by manufacture for BEA Economic Area 139 in 1970 was $410 million in 1967 dollars (Table 40). The projected 2020 value is $2.860 billion in 1967 dollars, an average annual rate of growth of 3.96 percent. The average annual rate of growth for the United States from 1970 to 2020 is 3.93 percent.

Table 42

EARNINGS BY MAJOR INDUSTRY, 1970-2020
BEA ECONOMIC AREA 139
(Thousand 1967 Dollars)

INDUSTRY	1970	1980	1990	2000	2010	2020
Agriculture	$ 97,900	$ 122,400	$ 131,700	$ 156,400	$ 204,100	$ 273,700
Mining	159,963	206,000	256,600	322,200	392,800	477,700
Contract Construction	127,918	173,000	234,900	329,900	462,300	651,100
Manufacturing	196,205	283,000	400,700	586,000	847,900	1,236,000
Transportation, Etc.	97,630	148,000	221,500	341,800	521,500	796,900
Wholesale & Retail Trade	217,251	323,300	458,500	672,100	979,100	1,433,900
Finance, Ins. & Real Estate	35,620	53,600	78,800	118,700	177,300	265,800
Services	161,034	255,500	386,300	598,100	911,800	1,383,200
Government	349,016	508,700	734,900	1,073,600	1,550,300	2,244,500
Total	$ 1,442,537	$ 2,073,500	$ 2,903,900	$ 4,198,800	$ 6,047,100	$ 8,762,800

SOURCE: OBERS

Value of farm products sold for BEA Economic Area 139 in 1970 was $157.6 million in 1967 dollars (Table 40) and is projected to be $440.7 million in 1967 dollars by 2020. The average annual rate of growth from 1970 to 2020 is 2.08 percent, fompared with the United States rate of 1.29 percent.

The 1970 mineral production values were taken from the Bureau of Mines Minerals Yearbook for 1970. The total value of mineral production for BEA Economic Area 139 in 1970 was $1.48 billion in 1967 dollars (Table 40). Minerals included in this figure were: natural gas, petroleum, natural gas liquids, sand and gravel, lime, salt, sulfur, and clays.

The 2020 value of mineral production is projected to be $4.41 billion in 1967 dollars. This reflects an average annual growth rate from 1970 of 2.21 percent compared with 2.04 percent for the United States. These projections were based on the factors of growth of mining earnings from the 1972 OBERS projections.

During 1970, four petroleum refineries were operating in BEA Economic Area 139 with a capacity of 280, 800 barrels per calendar day. Crude oil input for 1970 was estimated at 97.4 million barrels. Petroleum and related employment for 1970 totaled 4846.

Crude oil input projections for BEA Economic Area 139 are based on OBERS projected petroleum refining indices of output for Water Resources Subarea 808--Louisiana Coastal.

Projected employment figures were taken from the OBERS report for the area. Projections of crude oil input and employment indicate that annual crude oil input per employee will increase from 20,100 in 1970 to 59,600 in 2020.

6. Oil and Gas Resources 1/

As of February 1974, there were 5,892 active wells with 10,026 completion zones capable of producing oil and/or gas in the OCS of the Gulf of Mexico. All of these are located offshore Texas and Louisiana. Oil and gas production in 1973 from the OCS leases in the Gulf of Mexico accounted for approximately 342 million barrels of oil and 3.1 trillion cubic feet of gas with 1.6 billion gallons of gas liquids, with a total market value of $3.83 billion. Since the inception of the OCS leasing program, the cumulative value of offshore production in the Gulf of Mexico through 1973 has been $16.7 billion.

1/ USGS, Conservation Division. Outer Continental Shelf Statistics, February, 1974

H. Existing Environmental Quality in Nearshore and Coastal Zone 1/

1. Water Quality

Water quality of the coastal waters and rivers of Louisiana generally varies as to location and season of the year. Rivers east of the Mississippi within Louisiana generally have good water quality while lakes and bays (especially Lake Pontchartrain) have poorer quality waters. Even poorer water quality is encountered in the Mississippi River. West of the Mississippi River, water quality conditions are generally considered good except in the lower Calcasieu River and parts of Calcasieu Lake and Sabine-Neches complex.

Industrial wastes emptying into the Louisiana coastal waters were estimated by Perret et. al. (1971) at approximately 1,440 million gallons per day. Greatest discharges were into the Mississippi and Calcasieu Rivers. This is due to the extensive oil-chemical processing plants located in proximity to them. Other sources of industrial discharges include sugar refineries, fish processing plants, electrical generators and meat processors. In general, water quality parameters are not strongly deteriorated by industrial discharges along the Louisiana coast other than in the above-mentioned rivers.

2. Air Quality

Air quality over most of Louisiana is good, being better than ambient air quality standards in all but a few areas around heavy

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1/ This entire section excerpted from Report on Gulf Coast Deepwater Port Facilities. Appendix F Environmental Assessment Central Gulf. DOA Corps of Engineers, June 1973.

industrial complexes. Air quality was poorest in the Baton Rouge area near the heavy industrial complexes north of the city; suspended particulates, dustfall, sulphur dioxide and hydrocarbons exceed ambient standards. At the other station, Lafayette, Lake Charles and New Orleans, only suspended particulates consistently exceeded ambient standards during several months during 1971.

3. Noise

Little information is available on noise levels in southern Louisiana; however, levels would be expected to be highest around refinery plants, construction operations, and other areas where heavy machinery is involved. Lowest noise levels would probably be in the coastal marsh areas where little human habitation occurs.

4. Dredging

Deterioration of the environment by dredging can result from removal of benthos and benthic habitat in the path of the dredge, turbidity of the water and burial of the benthic community where the spoil is discharged, loss of aquatic habitat by emergent spoil banks, alteration of natural drainage and tidal patterns by deep channels and spoil banks, erosion and saltwater intrusion in wetland areas, resuspension of toxic materials previously buried in the sediments, and perhaps others. Dredging is carried out for several purposes: landfill operations, creation and maintenance of navigation channels and canals, sand and shell dredging, and pipeline laying. See section II.D. for description of the wetlands and section IV.C. for a more detailed discussion of impacts.

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III. Offshore Oil and Gas Operations

A. A Description of Oil and Gas Operations Including a Timetable for this Proposal

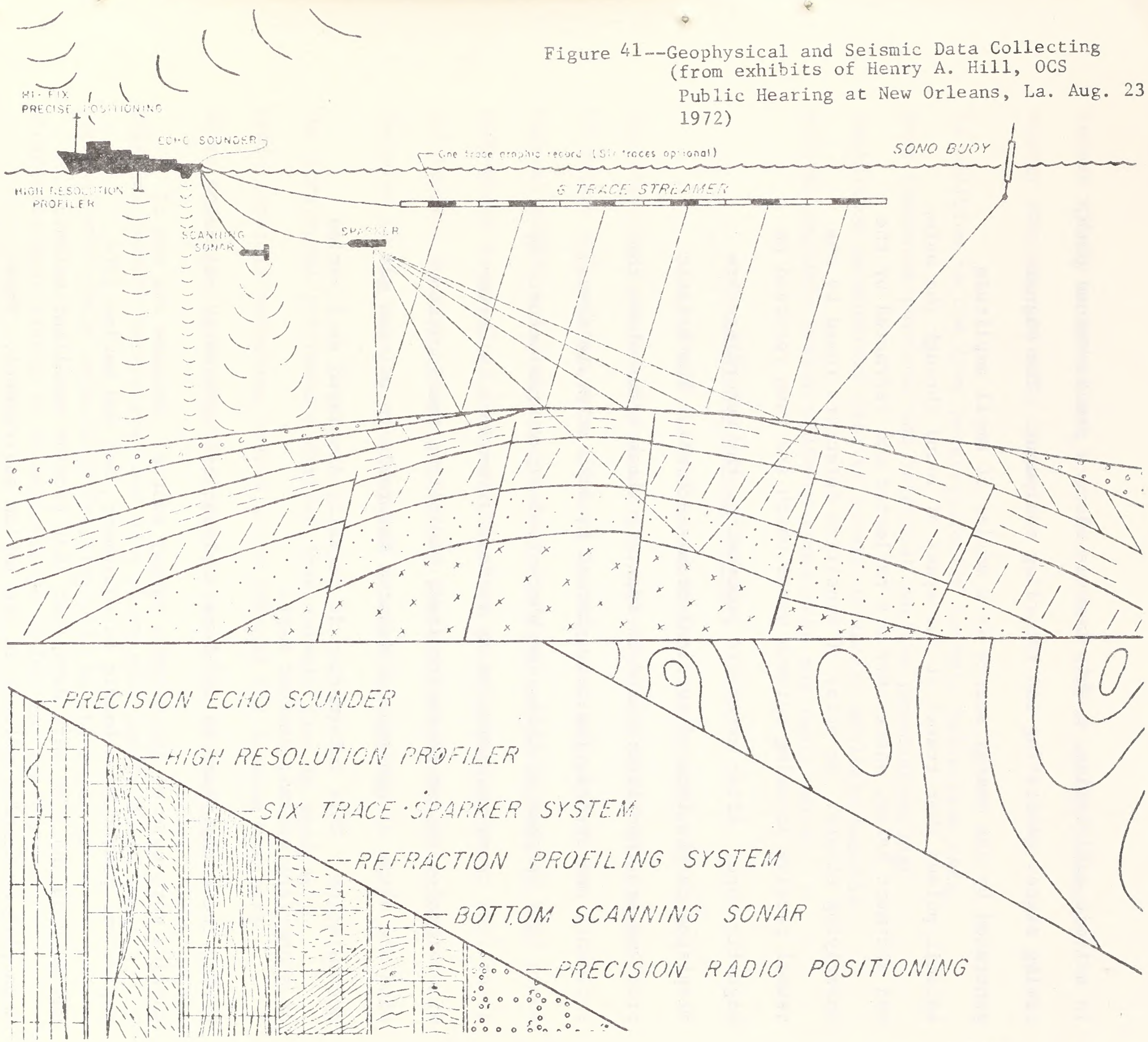
1. Geophysical Exploration

a. Industry

In order to locate hydrocarbon deposits, the oil industry must analyze the substructure of the continental shelf. The prime objective of the structural analysis is to locate geologic structures, which are favorable for the accumulation of petroleum. A knowledge of the subsurface geologic environment is also necessary to detect near surface conditions, such as recent faulting or high pressure zones, which are potential hazards to exploration and production operations. Once hazardous conditions are identified, drilling programs are modified to assure safety of operations.

Prior to a call for nomination of lease sale tracts, industry normally conducts regional geophysical surveys of an area of interest. These surveys provide a network of modern state-of-the-art common depth point (CDP) seismic lines on approximately a 4-mile-by-4 mile grid spacing to provide data for reconnaissance mapping. In some cases an even closer 2-mile-by-2 mile line spacing may be used. A typical high resolution data acquisition system is illustrated in Figure 41. After the tracts have been nominated, industry initiates the collection and interpretation of even more detailed seismic data in order to intelligently evaluate potentially productive tracts, and formulate reasonable bid offers.

Figure 41--Geophysical and Seismic Data Collecting (from exhibits of Henry A. Hill, OCS Public Hearing at New Orleans, La. Aug. 23 1972)



In seismic exploration, a ship travels along a predetermined path, towing signal generating and recording equipment. The signal generated by the energy source is a series of small amplitude seismic pulses that travel at the speed of sound through the water and sediment below, where they are reflected and refracted by the underlying strata. An array of sensitive detectors towed by the vessel receive incoming seismic waves which are then recorded on magnetic tape. After extensive processing, the recordings are displayed in the form of vertical cross-sections. The seismic profiles are then interpreted to identify those areas where the sediments are arched, faulted, pierced by salt or shale domes, where they thicken or thin, and where reef structures occur. By assembling cross-sections run in various directions, a three-dimensional view can be constructed, indicating the location, size and shape of geologic structures favorable to oil and gas accumulation. This information is normally displayed as a series of subsurface seismic contour maps.

During the early years of offshore exploration, underwater explosive charges were used as the seismic energy source. Because the use of explosives presented a hazard to equipment, men and marine life, new methods and gear were developed that provide excellent seismic data with no harmful effects on the marine environment. These modern devices, which include sparkers, air guns and gas guns have

become widely accepted and account for over 95% of marine seismic energy sources currently in use.

In addition to the deep penetration CDP seismic reflection data, some companies purchase and interpret shallow penetration high resolution geophysical data to locate potential geologic hazards such as unstable bottom sediment conditions and fault zones.

b. U.S. Geological Survey

The U.S. Geological Survey, Conservation Division, has acquired from industrial sources approximately 50,000 line miles of modern CDP seismic data offshore Louisiana in support of the Federal offshore leasing program. These data extend seaward to the 1000-meter water depth contour. The data provide definitive information on size, shape, type, and depth of prominent structural features in the area of the proposed general lease sale.

The structural information derived from seismic data is used as a basic input in selecting tracts to be offered for leasing and also shows the relative merits of potential traps for oil and gas.

Regional seismic interpretations have shown salt and/or shale domes, together with their associated faulting will be the types of structures most likely to be encountered within the northern Gulf province. These structural features are considered prime locations for the accumulation of hydrocarbons.

Detailed seismic interpretations of each proposed sale prospect are being prepared by the U.S. Geological Survey to support the economic evaluation of the acreage.

High resolution geophysical data which reveal shallow geologic structures, sediments, and faults are used to predict, and thus minimize, any hazards to drilling operations and possible consequent dangers to the environment from pollution. This information will also be used as a guide in regulating platform and well placements as well as drilling procedures. This subject will be discussed more completely under "Mitigating Measures" section IV.

Approximately 18,450 line miles of high resolution data, comprising a 2x2 mile and 1/2x1-1/2 mile survey grid over the Louisiana OCS and slope (between 200 and 600 meters) have been collected. In addition, procurement action will be initiated by the USGS to acquire the necessary data covering all tracts to be offered.

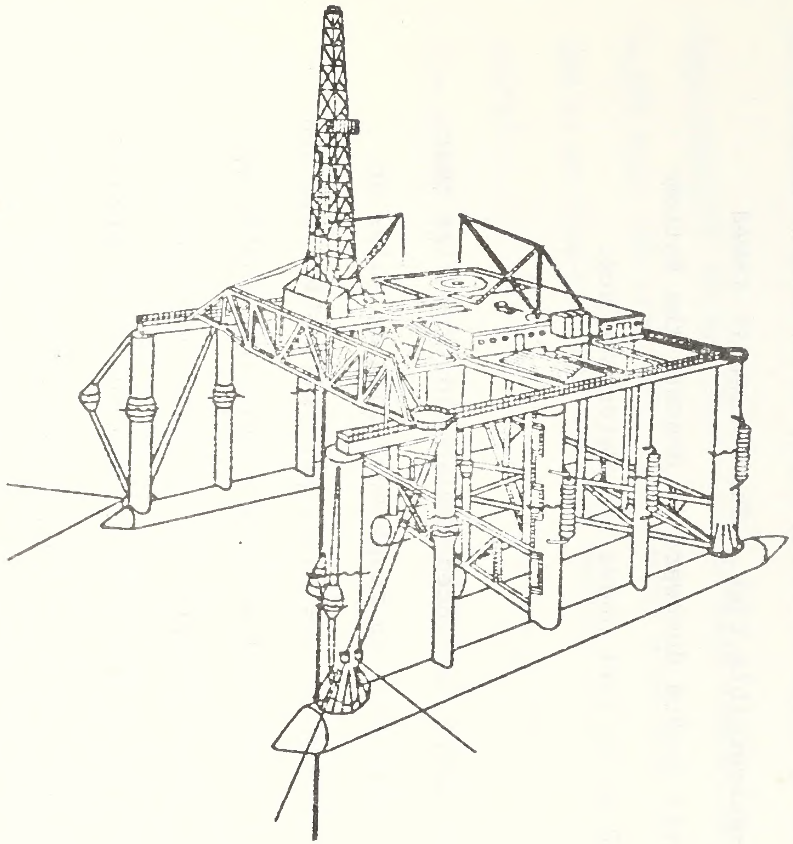
2. Exploratory Drilling

a. Drilling Phase

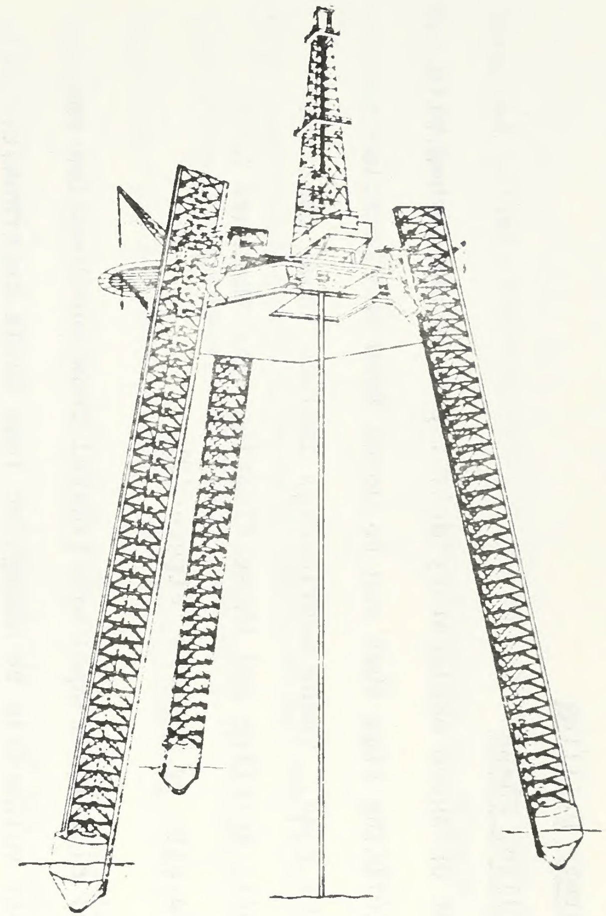
Most offshore exploratory drilling is accomplished with the use of mobile drilling rigs that can be moved from one location to another with relative ease. These mobile rigs include those that are bottom-supported while drilling and those floating rigs that are held in position over the site by anchors (Figure 42).

The bottom supported rigs (jack-ups) are floated from one location to another, and are most vulnerable to damage or loss while in transit. Shallow (less than 300 feet) water exploratory drilling is commonly carried out using a "jack-up" type drilling rigs, while deeper waters require the use of semi-submersible rigs. The former is towed into position and the legs jacked downward to contact the bottom and lift the platform 30 to 50 feet above the water surface.

The semi-submersibles are large, advanced-design floating rigs that have better motion characteristics in rough seas than do ships or barges. These rigs are floated to the site, partially submerged and held in place by anchors. These units can work in water depths up to 1000 feet and beyond. At this depth, (37 of the tracts being offered have water depths from 300 to 500 meters) the major problem is keeping the drilling vessel properly aligned with the drill hole on the sea floor. One method has been to connect the wellhead (on



Once anchored in place, the semi-submersible is used to drill wildcat or exploratory wells in depths up to 1,000 feet and beyond.



With elevating legs, the jack-up rig can be floated to location and then raised or jacked up on the legs to appropriate height above water. This rig is normally limited to about 300-foot water depths.

Figure 42. Exploratory Drilling Rigs (From "The Offshore Search for Oil and Gas Exxon Background Series No. 2R, November, 1972).

the seafloor) with the drillship by a drilling riser pipe which is tensioned at the top to maintain its structural integrity. The tension requirements can be reduced by attaching buoyant material to the riser; in fact, analysis indicates that buoyant risers can be designed for water depths of 3000 feet (approximately 915 meters). Winds, waves and ocean currents tend to push the drillship off location regardless of how good the mooring system. This can put excessive stresses on the riser. One company uses an acoustic position reference system whereby acoustic signals from an acoustic beacon located near the wellhead on the seafloor are received by three shipboard hydrophones. In use, the vessel's position is determined by comparing, at each of the three shipboard hydrophones, the signal emitted by the seafloor beacon. The correct position, with reference to the wellbore, is shown on the shipboard console viewing screen and the vessel kept in position by adjusting mooring lines or using the ships engines plus special horizontal thruster engines. If, for some reason the drillship should have to move off location, the seafloor beacon is used to reposition the vessel upon return.

Submarine blowout preventers have been improved to the point that they can now be used in any water depth with closure time of less that 10 seconds.

A diagram of the buoyant riser, acoustic position reference system and submarine blowout preventers is shown in Fig. 43.

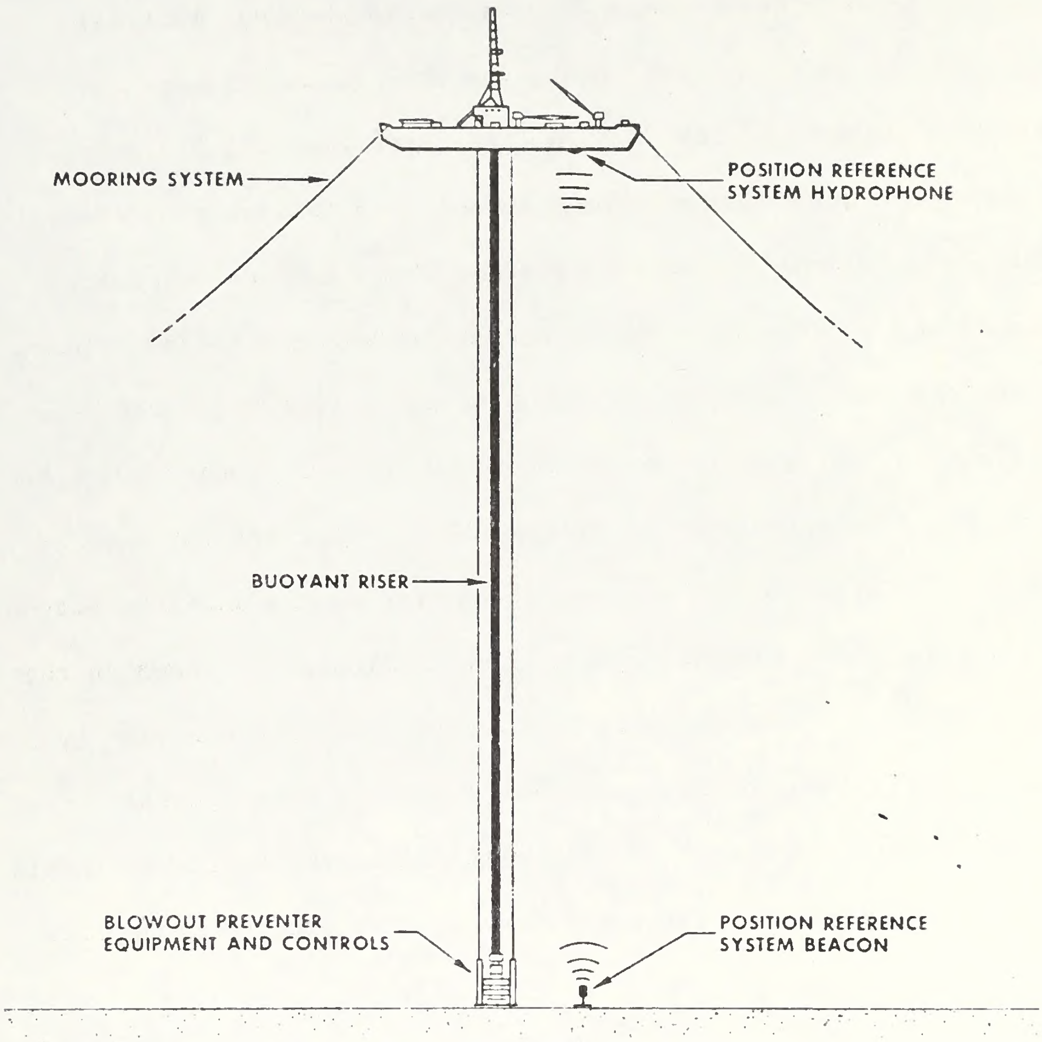


Figure 43. Components of a Deepwater Exploratory Drilling System
(From Deepwater Capabilities ESSO Production Research Company.)

The deepest water depth for floating drilling in the Gulf of Mexico was 536 feet in 1973. However, drilling operations in much greater water depths have been accomplished in other areas, and technology currently exists for deeper operations in the Gulf of Mexico. In the Santa Barbara Channel over 30 wells were drilled and production tested in water depths greater than 500 feet, four of which were in water depths approaching 1500 feet. This technology is directly applicable to the Gulf of Mexico.

Exploratory drilling by mobile rigs is regulated and inspected by the USGS and the Coast Guard. The scope of these regulations include personnel safety equipment, rig power system, pollution control procedures, casing setting procedures, mud program, and drilling safety equipment. Failure to comply in any of these items can result in suspension of rig activity until corrections are completed. 1/

1/ Statement of C. C. Taylor, Dept. of Interior Hearing, Louisiana Offshore Annual Sale Number 33, November 28-29, 1973. Edited.

In drilling, two distinct, important pressures must be considered. One is the pressure within the geologic formation penetrated and the other is the pressure required to fracture or allow the drilling fluid to enter the formation below the last casing string and above the drill bit. These pressures are naturally occurring phenomena. A drilling plan calls for maintaining a sufficient hydrostatic gradient to prevent formation fluids from flowing into the wellbore. This is done by adjusting the density or weight of the drilling fluid or "mud" that is continuously circulated through the drill string to provide pressure control, lubrication of the drill bit, and circulation of wellbore cuttings out of the hole (Fig. 44).

In spite of considerable research, it is still not always possible to predetermine, for wildcat wells, the formation pressure and the fracture pressure that the wellbore will encounter. During drilling there are several means of determining the trend in pressure. They include measurements such as formation temperature (as evidenced by the temperature of the returning mud), shale density and changes in the penetration rate of the drill bit.

If the hydrostatic gradient of the drilling fluid becomes less than formation pressure, a "kick" of gas or other fluid may enter the wellbore from the formation being drilled. The influx displaces some drilling fluid, thereby causing reduction in the hydrostatic head in the annular space between the drillpipe and the borehole (Fig. 45).

Example of Well Bore and Casing

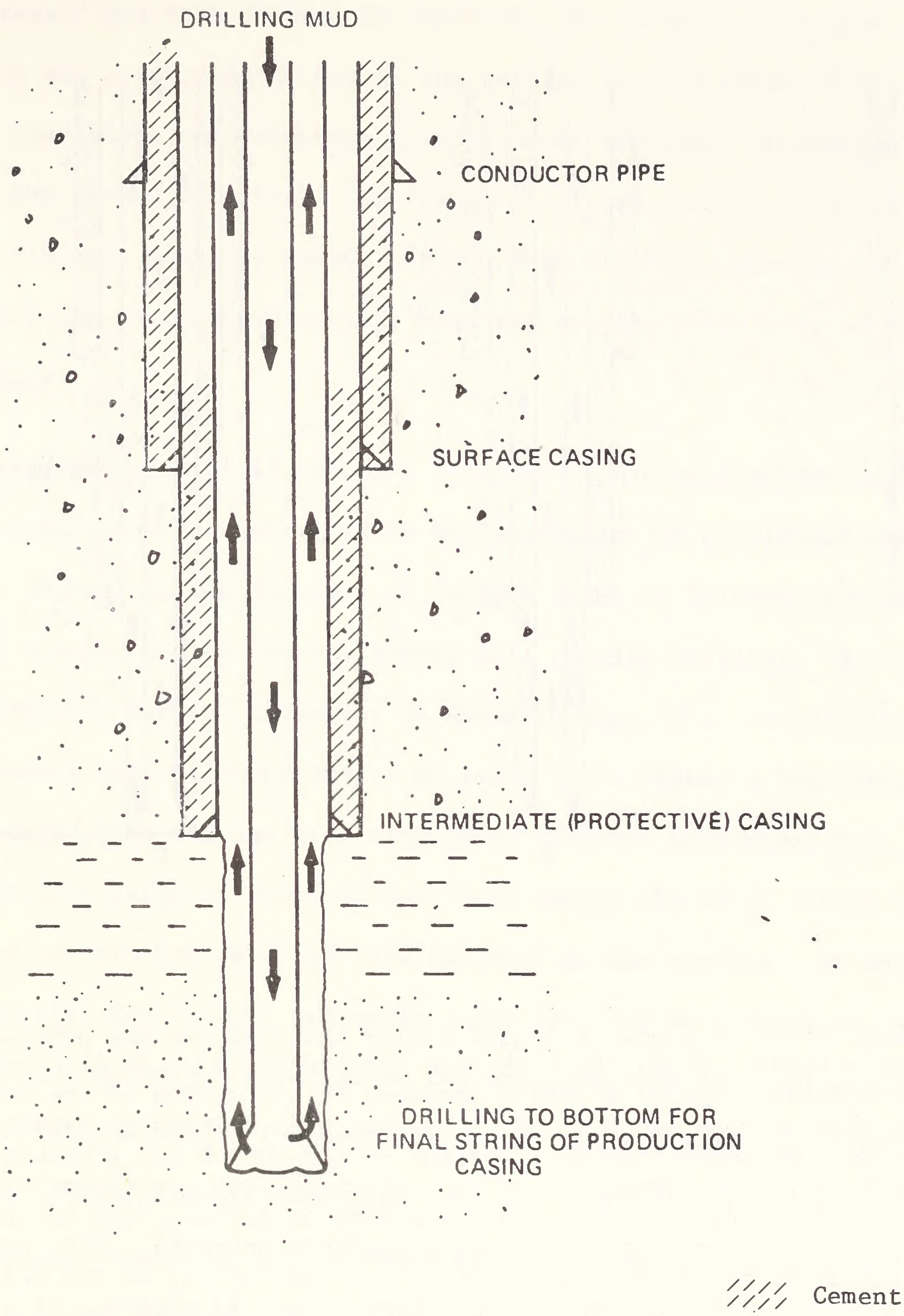


Figure 44. The drilling mud circulates down through the drill pipe and up the annulus. The relation between the mud pressure gradient and the formation fracture gradient is critical.

(Adapted from Panel on Operational Safety in Offshore Resource Development, "Outer Continental Shelf Resource Development Safety," Marine Board of National Academy of Engineering, Dec., 1972.)

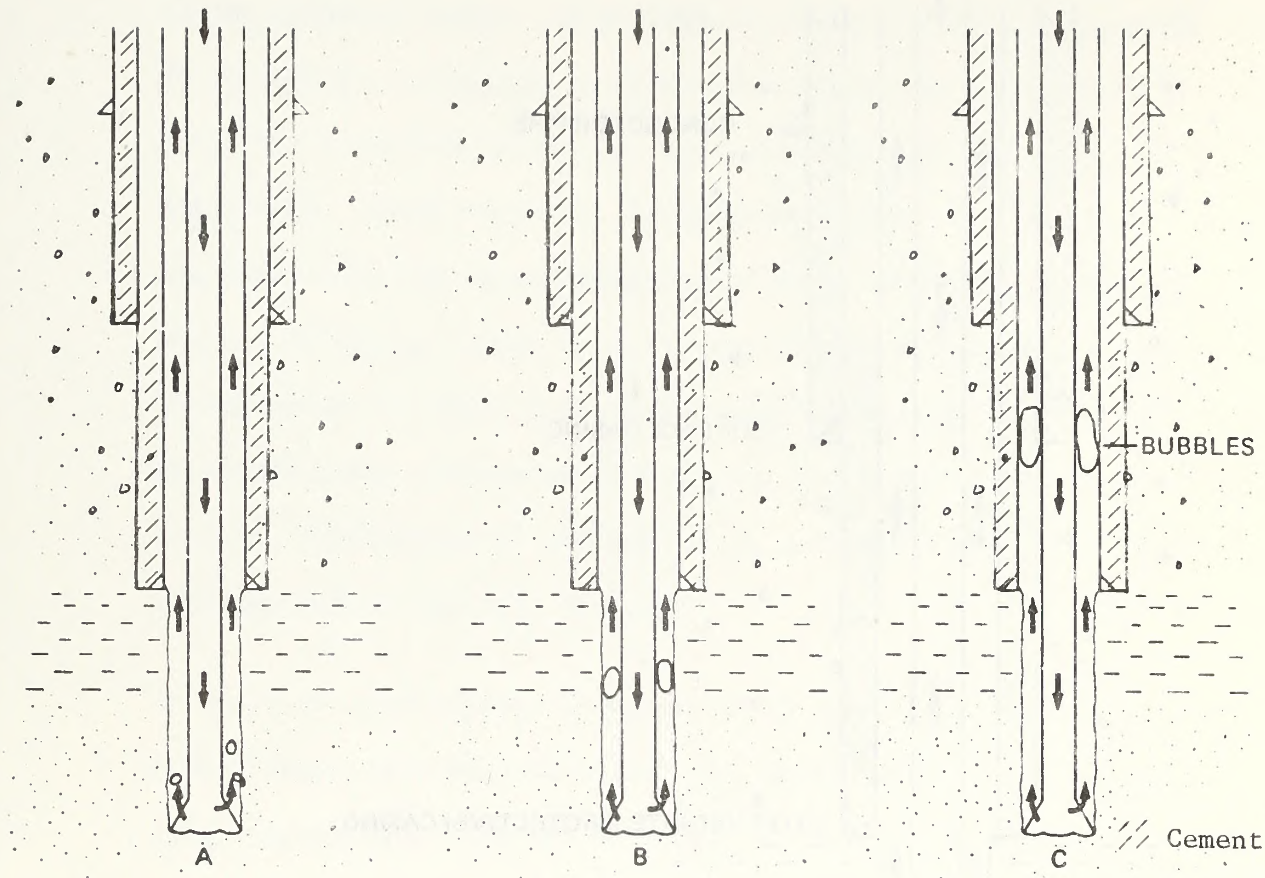


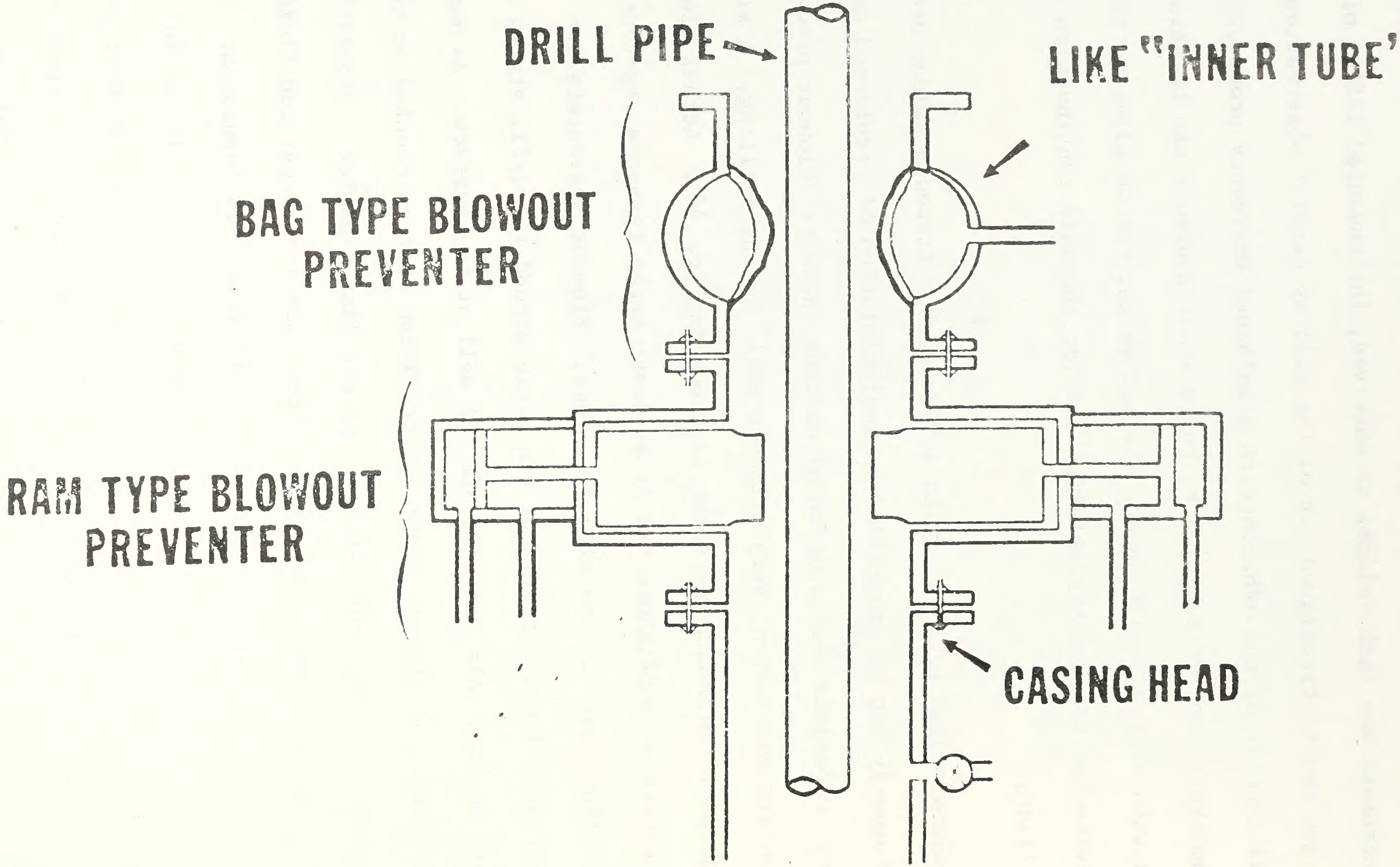
Figure 45.-A "kick" is a gas or liquid influx that reduces the hydrostatic head in the annulus. Here, the kick is a gas bubble (A). As it rises (B and C), it expands--causing a sudden increase in the upflow of the mud. When the bubble reaches the top, if it has not been allowed to expand, the bottom-hole pressure reaches a maximum -- the sum of mud pressure and gas pressure. This pressure maximum, if excessive, can exceed the formation fracture pressure, and lead to a loss of drilling mud to the formation, thus further decreasing the hydrostatic pressure. This could cause an influx of formation fluids into other formations, or the fractured formation taking fluid from another formation, commonly referred to as an underground blow out.

(Adopted from Panel on Operational Safety in Offshore Resource Development, "Outer Continental Shelf Resource Development Safety", Marine Board of National Academy of Engineering, December, 1972).

If the volume of the influx is not excessive, and a surface indication (increased mud tank volume) is observed, the unwanted influx of fluid or gas can be circulated out of the well by careful observation of well conditions and adherence to preplanned emergency procedures. From the record of a kick, the bottom-hole pressure can be determined and with this pressure known, the mud weight can be adjusted to provide the correct hydrostatic head for the safe continuation of drilling.

An uncontrolled kick is called a "blowout". Blowouts seldom occur and usually can be controlled by implementation of preplanned emergency procedures and actuation of devices known as "blowout preventers" which are mounted on every offshore well during drilling. A simplified diagram of a blowout preventer is shown in Fig. 46. Actual blowout preventers used offshore are of at least three types; a bag-type, one with blind rams and one with pipe rams. Blowout preventers are essentially large valves that can close around the drill string or across an open hole and seal off the well at the surface. As mentioned previously, the blowout preventer stack can also be mounted on the sea floor and remotely controlled at the drilling console. Blowouts can occur downhole when a low-pressure formation fractures, and fluids from a higher-pressure zone flow into the fractured formation. Such underground blowouts, like surface blowouts, require the careful use of preplanned emergency techniques to regain control. Blowout preventers and other well-control equipment must meet the requirements of OCS Order No. 2. This equipment is tested on a schedule set by prudent practice, but not less often than regulations specify.

Figure 46 -- BAG TYPE AND RAM TYPE BLOWOUT PREVENTERS



(From testimony of Bob G. Murphy on behalf of the Offshore Operators Committee at a public hearing in Houston, Texas, on February 22, 1973.)

To ensure that adequate provisions have been made for safety and well control, the casing program and drilling fluid, or mud, program must be approved by the Geological Survey before a drilling permit is issued. Along with adequate casing, it is important that enough cement be spotted between the casing and the wall of the hole to seal off and isolate all sensitive geological formations such as hydrocarbon zones and freshwater sands, and to separate zones of abnormal pressure from those with normal pressures.

b. Well Completion Phase

Should the initial test be dry, the well is usually plugged and abandoned. Cement plugs are set to confine formation fluids in their parent subsurface formations to prevent them from intermingling and to prevent flow to the surface. During plugging operations, well-control equipment remains in use. When a well is abandoned, the casing is cut-off at least 15 feet below the mud line, all obstructions are removed, and the bottom is dragged to be sure that no obstructions were overlooked. In some cases, it may be necessary to drill several exploratory wells on each block before the lease is totally condemned.

Fluids from formations penetrated by wells are often brought to the surface in drill-stem tests to evaluate the possibility of oil and natural gas production. These fluids are collected in tanks at the surface; drilling mud is separated from the produced fluid, and if the formation fluid is oil it is stored for later disposition; or,

the oil and natural gas are flared in specialized, high volume burners.

If well tests show that commercial quantities of natural gas or oil have been found, it may be necessary to do several additional confirmation tests before the company is satisfied that the reserves will support a development drilling and well completion program.

It is also important to delineate as precisely as possible the extent of the petroleum reservoir because of the extreme expense of deeper water platforms and the economic necessity of drilling as many production wells as possible (sometimes over 30) from a single platform. Platform location in relation to hydrocarbon deposits must be extremely accurate to minimize the number of platforms installed.

If petroleum deposits prove to be commercial, one of two courses of action may be followed:

(i) The exploratory well may be deemed expendable and be permanently abandoned. Procedures followed would be the same as above for a dry-hole abandonment.

(ii) The well may be deemed useful as a future production well and temporarily abandoned. In this case, a mechanical bridge plug is placed in the smallest string of casing and the well head capped and left for future entry when production activity commences. This results in the temporary existence of an underwater

"stub". The Coast Guard District Commander requires that such stubs be marked by a buoy at the surface if located in 200 feet of water or less, and that the buoy be lighted if located in 85 feet of water or less.

3. Development Drilling, Production and Workover 1/

a. Platform Installation and Production Well Drilling

Offshore drilling and producing operations are usually conducted on fixed, bottom-founded, water surface-piercing platforms (Fig. 47). If exploratory efforts are successful in proving a hydrocarbon reserve, production operations are initiated by installing platforms (Fig. 47) to serve as a base for drilling development wells and for subsequent production operations. A number of wells may be directionally drilled to develop a large area from a single platform. Many platforms in the Gulf today contain as many as 20-30 wells.

During the 27-year history of oil operations in the Gulf of Mexico, industry has gained a good understanding of the physical forces acting on offshore platforms. Therefore platform design is a matter of selecting the optimum geometry and sizing structural members based on appropriate safety factors to withstand maximum anticipated environmental forces and operational loads. Appropriate design procedures are outlined in API Recommended Practice RP 2A and various API specifications. These guidelines have been prepared to cover engineer-

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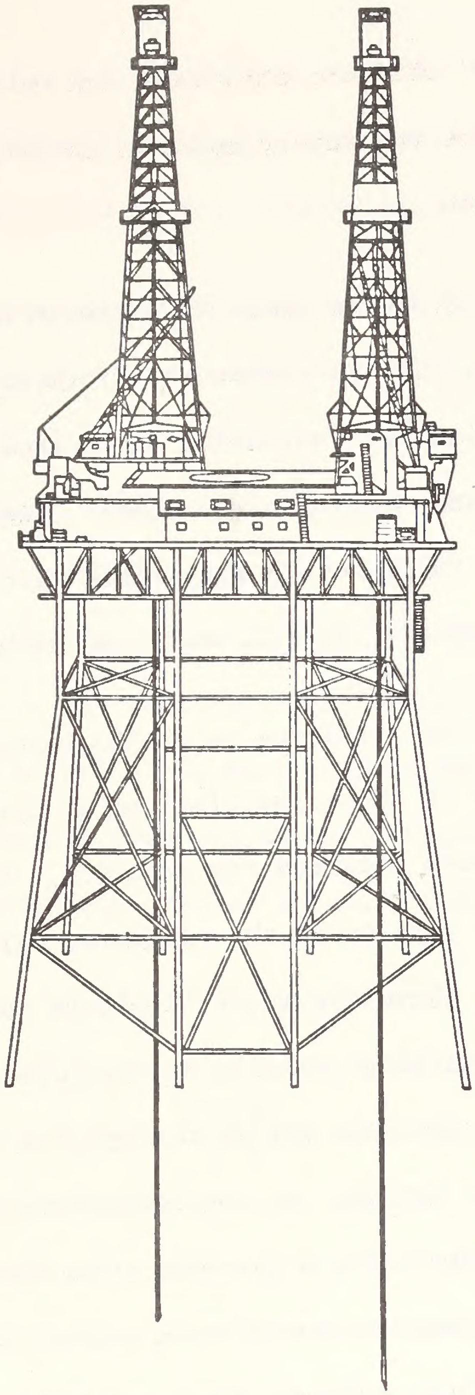
1/ Much of the information in this section has been excerpted from Statement of C. C. Taylor, Dept. of Interior Hearing, Louisiana Offshore Annual Sale No. 33, November 28-29, 1973.



Rigs mounted on fixed platforms, used for development drilling after an oil or gas discovery, permit drilling up to thirty wells from a single platform and location. After drilling, the rigs are removed, and the platform is used for production.

Figure 47--Fixed Production Platform

(from "The Offshore Search for Oil and Gas," Exxon Background Series No. 2R, Nov., 1972, Public Affairs Dept., Exxon Corp.)

ing design and operation of offshore structures and related equipment. USGS OCS Order No. 8 defines regulatory approval procedures for platform design and installation.

Platforms have been installed in the Gulf of Mexico in water depths to 373 feet, and technology exists to extend platform operations to much greater depths. Platforms are now being fabricated for installation in the North Sea in water depths to 460 feet. A design for installation in 850 feet of water at the Santa Ynez Unit in the Santa Barbara Channel has been completed and is ready for implementation.

The primary new requirement for platforms in depths beyond current operations is for procedures to erect the platform at the offshore site or for floating to the offshore location for erection. During the first stage of erection, the lower portion of the platform, which extends from the ocean floor to just above the water level, is set in a vertical position on the ocean floor usually by controlled flooding of the structure legs. Pilings are then driven through the structure legs to secure the platform to the bottom. In the second stage of erection the platform deck is installed on the supporting structure. Large platforms in deep water will require use of more and/or larger lifting, transportation, and installation equipment than shallow water platforms. However, once set and secured with pilings, subsequent platform operations are identical to those that have been proven safe in current operation. No technological limitation in platform installations in water depths to at least 1000-1200 feet (300-360 meters) are apparent at this time; thus

more than 87% of the 295 tracts proposed for lease in this sale should be able to be developed in the conventional manner.

Buoyant towers have potential applications in water depths greater than about 1000 feet. These towers are pivoted at the base and are stabilized in a vertical position by buoyancy chambers. Unlike conventional platforms, bouyant towers sway under the action of wave forces instead of resisting them. In waters much less than 1000 feet deep, however, the sway of these towers would be excessive. Towers that would support two drilling rigs, production equipment, and 40 to 60 wells appear feasible for water depths between 1000 and 2000 feet. One concept of such a tower is shown in Figure 48 . This type drilling platform has never been used on the U.S. OCS.

The drilling rig, power plants, generators, living quarters, storage sheds and other components, constructed in modular form, are added to the platform, and production well drilling commences. Equipment anticipated for use on deep water platforms is similar to that being used safely in current shallow water operations, and will be installed and operated in accordance with safe practices accumulated from industry experience. These practices form the basis of USGS OCS Order No. 8, which gives the safe practices a regulatory mandate. This order specifies multiple, redundant controls and safety devices including safety shut-in valves, high-low pressure pilots, high-low level controls, high-temperature shutdowns, gas detectors, shielded ignitions, fire prevention and detection equipment, and pressure relief systems. Drain and sump systems are also designed to collect any spillage that might occur on the

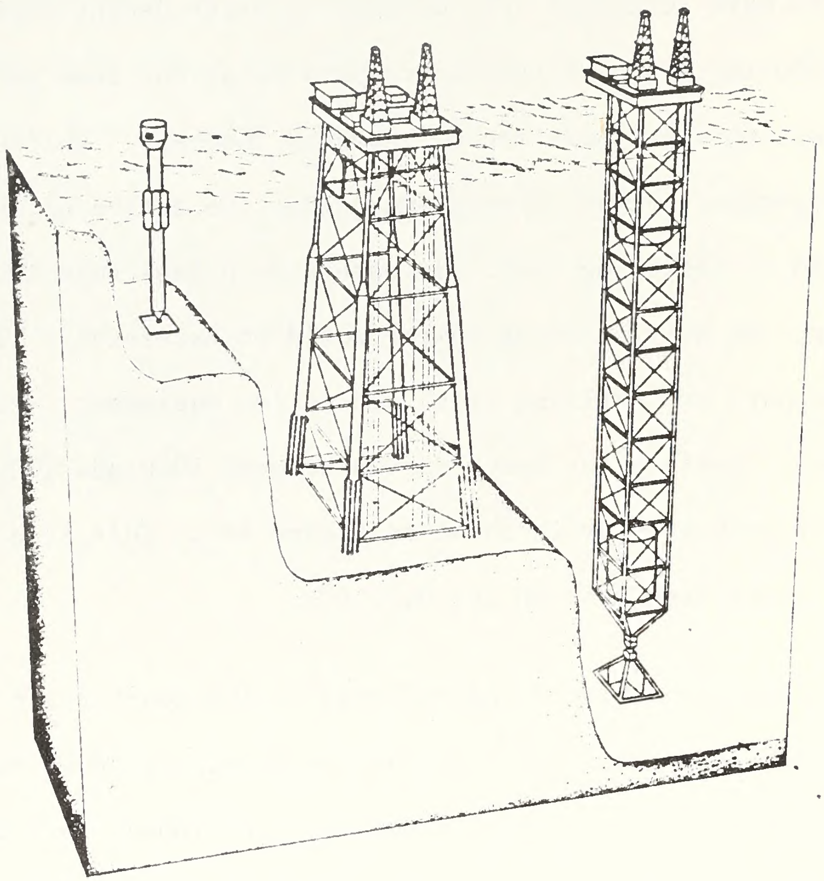


Figure 48. French test of buoyant tower in 325 feet of water, compared with Esso concept of 700-foot platform and 1350-foot tower.

(from Deepwater Capabilities Esso Production Research Company.)

platform. The sequence of drilling operations for production wells is essentially the same as for exploratory wells.

As water depths increase, the economic desirability of seafloor completions and, in fact, an entire subsea production system increases. Considerable progress has been made in this direction. One system allows non-divers, oil field mechanics and technicians to work on the wellhead on the seafloor in a one-atmosphere climate by lowering them in a work chamber which can be sealed to the base of the wellhead and evacuated to atmospheric pressure. Other systems comprising complete producing facilities (pumps, separators, treater, etc.) are in various stages of developments. The safety equipment used in subsea systems is similar in concept to that used in current operations and will provide the same high degree of environmental protection. The systems are designed such that a failure condition will automatically shut-in the affected part of the system. As with platform wells each subsea well will be equipped with a subsurface safety valve that can be actuated and tested on a frequent basis. It is emphasized that subsea completion techniques are still in the development stage. The Shell Lockheed system, designed for 3000 feet of water, is being tested in 375 feet of water.

Subsea completions will result in seafloor obstructions that could foul trawling gear; however, only a small portion of the total trawling effort takes place at depths where subsea completions are most likely to be used. Should a trawl snag a subsea completion the possibility that it would damage any of the well head assembly to the extent of causing uncontrolled flow is extremely remote because of the strength and durability of

the material that would be used in the seafloor structure.

Wells usually are produced through tubing placed inside the final or production string of casing. During tubing installation, the blowout preventers remain in use to ensure control of the well. A system of in-tubing safety valves, plus other casing and tubing valves at the surface or seafloor, is installed to control well flow. Actuation is usually at the producing platform. A wellhead, consisting of several redundant control valves, is installed at the platform lower deck level and subsurface safety valves are installed at depths varying from a few hundred to several thousand feet in the tubing string.

Of major concern in the operation and control of every production platform are the downhole control devices. Production tubing is fitted with one or more safety valves that are installed and located at least 100 feet below the mud line or seafloor. In the past, velocity choke valves ("storm chokes") designed to shut off production when the flow rate exceeds predetermined limits have been used. Such valves should close if surface equipment failure results in an excessive flow through the tubing. These chokes are particularly susceptible to failure from internal erosion in areas where sand is produced along with the oil and gas.

Certain types of subsurface fail-safe valves do not depend on the velocity of well fluids for actuation, but are held open by hydraulic or other fluid pressure applied from the surface. The valve is designed to close automatically, shutting off the flow of fluid from the well in the event of some undesirable situation of the platform. Essentially all wells drilled since December 1, 1972, are

equipped with valves that are actuated from the surface. These valves provide highly reliable protection and may be tested frequently to insure proper operation. Their use will increase costs significantly, but the need for more reliable valves has been shown by recent incidents in the Gulf of Mexico and elsewhere. The increased degree of safety offered by use of the fail-safe valves probably justifies their installation.

Blowout preventers as well as downhole control devices have proven to be extremely valuable, in time of accidents and emergencies, in preventing large amounts of oil from escaping into the environment. When hurricanes have passed through offshore oil and gas fields, entire platforms have been swept away with only a minimal spillage of oil (see Section II.B.7.a.).

b. Disposal of Drill Cuttings and Drilling Mud

The following information was furnished by the Geological Survey and the petroleum industry and pertains to the drill cuttings and drilling mud discharges from a typical offshore well which is assumed to be:

1) a development well (not exploratory)

2) drilled from a multi-well slot platform using a standard platform mounted rig

3) a "normal" well, i.e., one in which no special drilling problems or mud problems are experienced which would cause an abnormal volume of cuttings or usage of mud

4) drilled to a total depth of 10,000 feet.

This typical 10,000 foot offshore well generates approximately 2,400 barrels of cuttings weighing about 700 tons. To drill this well seawater drilling mud containing almost 300 tons of mud components are used. The total weight of cuttings and mud components discharged overboard is some 800 to 900 tons per well. Average drilling time is 10 to 14 days; therefore, the amount of drill cuttings and drilling mud components discharged into the Gulf of Mexico must average about 70 tons per day per <u>drilling</u> well. All discharges must, of course, comply with OCS Order No. 7 (Attachment A).

The casing program for this well consists of four strings:

1) the structural casing, (drive pipe) is usually 30 inches in diameter. It is set to a minimum depth of 100 feet to provide stability in unconsolidated sediments
2) the 16-inch conductor pipe, set at 900 feet
3) the 10 3/4-inch surface casing, set at 3,500 feet
4) the 7-inch production string, set at 10,000 feet.

Table 43shows the volume of cuttings generated by the typical 10,000 foot well.

Table 43. Volume of Drill Cuttings Generated in Typical 10,000 Foot Offshore Well

Interval (feet)	Hole Size (inches)	Volume of Cuttings (barrels)	Weight of Cuttings (pounds)
0-900	24	504	408,000
900-3500	18	843	680,000
3500-10,000	13	1100	890,000
Total		2447	1,978,000

As the drilling fluid-drill cuttings mixture is circulated to the surface, drill cuttings are separated from the drilling fluid by shale shakers, desilters, and desanders, and discharged overboard.

Approximately 7,000 barrels of seawater drilling muds are used to drill this typical offshore well. Almost 300 long tons of commercial mud components are used to make up and maintain the drilling muds in the well. Conditioning of the mud system in order to maintain the desired mud characteristics requires some overboard discharge of clay solids in the mud and an addition of commercial mud and seawater to the system daily. Table 44 shows typical quantities of commercial mud components used to drill a well to 15,000 feet on the OCS. The intervals between usual casing points is used so some rough interpolations can be made. The top 900 foot section of the well is drilled with a mixture of seawater commercial mud components (barium sulfate, clays and caustic) and the natural mud and clays from the surface formations that are drilled. Shale particles and sand are discharged overboard as this secion of the hole is drilled.

Prior to installation of the 16" conductor pipe in the hole, a gelled seawater mud is mixed and spotted in the well bore, and the natural mud system is discharged overboard after first recovering most of the barium sulfate. This gelled seawater mud is used to drill the next 2,600 feet of hole. Table 44 shows the weight and various components used to make up and maintain the required characteristics of the mud while this interval is drilled. A total volume of 700 barrels is made up and maintained in the system.

Table 44. Mud Components used in seawater - Lignosulfonate Systems to 15,000 feet. Weight in pounds 1/

Component	Interval 0-900 Feet	Interval 900-3500 Feet	Sub-total 3500 Feet	Interval 3500-10,000 Feet	Sub-total 10,000 Feet	Interval 10-15,000 Feet	Total 15,000 Feet
Barium Sulfate (Barite)	3,000	3,000	6,000	529,000	535,000	625,000	1,160,000
Bentonitic Clay	10,000	10,000	20,000	36,000	56,000	9,000	65,000
Attapulgite Clay	5,000	5,000	10,000	-	10,000	-	10,000
Caustic	500	500	1,000	20,000	21,000	23,000	44,000
Aromatic Detergent		1,000	1,000	2,000	3,000	-	3,000
Organic Polymers		1,000	1,000	3,000	4,000	-	4,000
Ferrochrome Lignosulfonate				26,000	26,000	69,000	95,000
Sodium Chromate						2,000	2,000
Totals	18,500	20,500	39,000	616,000	655,000	728,000	1,383,000

1/ It is emphasized that these are "typical" values and quantities may vary by as much as 50% from well to well.

Before drilling out of the 10 3/4-inch casing, the gelled seawater mud is converted to a ferrochrome lignosulfonate mud for drilling the final section of the hole. The conversion is effected by adding seawater, ferrochrome lignosulfonate and other materials. This conversion may be done deeper in the hole, depending on the geologic formations being drilled.

When drilling is resumed after the conversion, the mud system volume is expanded to 950 bbl., in order to allow for deepening of the hole. Table 44 also shows the weight of the various components used to make up and maintain the characteristics of ferrochrome lignosulfonate mud while drilling the final 5,500 feet of hole. After the 7-inch production string of casing is set, about 550 barrels of mud in the tanks in the surface mud system are saved for use in drilling the next well. The 400 barrels remaining in the well is discharged overboard after most of the barite has been removed by centrifuge. After the final well is drilled, the barite is often barged ashore for resuse at other locations. Barite is barium sulfate ($BaSO_4$) with a sp. gr. of 4.5 and a solubility of less than 0.0004 grams per 100 ml. of water; thus any of this material not removed by certrifuging and dumped overboard would sink very rapidly and would dissolve very slowly. The commercial value (cost) of the barite will tend to keep any dumping to a minumum. Chromium is known to be toxic, either as an element or in low concentration of various compounds.

Ferrochrome lignosulfonate has been shown to be toxic to freshwater fish in concentrations greater than 1000 ppm (LC50 at 96 hours) 1/. This toxicity is apparently due to a toxic iron (not chromium) compound that forms in an acid environment (personal comm. with a biologist from Magnabar, a mud supply company). The mud supply companies are switching to a chrome lignosulfonate component which has no iron, performs just as well, and shows no harm to fish after 96 hours at concentrations greater than 10,000 ppm. Sodium chromate is a potentially toxic material which is occasionally (not always) used on deeper completions, and then only in relatively small amounts. See Vol. 2, pp. 5-6 for additional discussion of chromium.

Special Cases

Occasionally, abnormal formation pressures, exceptionally tight formation, or other problems require the use of oil-based or highly treated drilling muds. Drill cuttings are then separated and cleaned of entrained oil before being discharged overboard, and the drilling muds are retained and shipped to shore and stored in tanks for future use.

c. Produced Formation Water

The waters associated with oil and gas pools which are frequently produced along with the oil and gas are called forma-

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1/ Falk, M. R. and M. J. Lawrence. 1973. Acute toxicity of petrochemical drilling fluids components and wastes to fish. Tech. Rept. Series No. CEN-T-73-1. Resource Mgmt. Branch, Dept. of Environment, Freshwater Inst., Winnipeg, Manitoba.

tion waters. The lower edge or boundary of most oil and gas pools is marked by oil-water or gas-water contact. In some pools, water is produced with the oil in early stages of production, whereas in others, appreciable water is never produced with the oil.

Most formation waters produced in the Gulf of Mexico are brines, characterized by an abundance of chlorides, mostly as sodium chloride and have concentrations of dissolved solids several times greater than that of seawater. The total amount of mineral matter commonly found dissolved in oil-field waters ranges from a few milligrams per liter (mg/l), nearly fresh water, to approximately 300,000 mg/l, a heavy brine.

The following table (Table 45) shows the content of three representative brines: (1) high solids, (2) average solids, and (3) low solids. The average total dissolved solids of 76 samples from southern Louisiana and the Outer Continental Shelf was found to be 112,513 mg/l with a high of 270,400 mg/l and low of 61,552 mg/l. Note that they commonly contain varying amounts of iron, calcium, magnesium, sodium, bicarbonates, sulphate, and chloride, with sodium and chloride being the most abundant ions.

Total formation water production from all OCS operations offshore Louisiana is about 603,000 barrels per day; 305,000 barrels per day are transported to shore for treatment and release, and the remaining 298,000 barrels per day are treated and discharged near the platforms.

Table 45. Chemical Content of Representative Offshore Brines 1/

Component	High Solids		Average Solids		Low Solids	
	Mg/1	%	Mg/1	%	Mg/1	%
Iron	153	0.057	15	0.011	139	0.226
Calcium	17,000	6.287	4,675	3.294	772	1.254
Magnesium	2,090	0.773	1,030	0.726	152	0.247
Sodium	84,500	31.250	49,120	34.612	22,651	36.800
Bicarbonate	37	0.014	100	0.070	933	1.516
Sulphate	120	0.044	0		188	0.305
Chloride	166,500	61.575	86,975	61.287	36,717	59.652
Total Solids	270,400	100%	141,915	100%	61,552	100%

1/ From U.S. Geological Survey, Oil and Gas Supervisor, Gulf of Mexico Area New Orleans, Louisiana.

It is highly unlikely that any of the produced formation water resulting from this sale would ever be piped ashore. Both economic and environmental considerations weigh heavily towards choosing to treat and release the water into the ocean at the platform site or reinject it into subsurface formations. In nearly all cases, reinjection is utilized as a secondary recovery technique by pumping formation water, under pressure, back into the lower levels of the petroleum-producing zone and thus maintaining good reservoir pressure. Formation water which is to be discharged into the ocean is first passed through a water-treating facility that removes all but traces (maximum permissible average = 50 ppm) of entrained oil. However, the water is still void of dissolved oxygen and contains large quantities of dissolved minerals.

d. Solid Waste Disposal

All solid waste accumulating from daily drilling and production operations is collected in large containers constructed of heavy grating. To reduce the bulk before being transferred to shore, wastes are sometimes compacted in mechanical compactors but are generally incinerated in burn baskets suspended from the platform. Ashes are allowed to fall into the water. Non-combustible solids are then loaded into service boats for transfer to shore. Solid wastes, transferred to shore, are emptied into municipal or private sanitary landfills which are subject to the sanitary landfill laws of the State.

Sewage treatment and disposal on offshore rigs and platforms is very similar to the common septic tank, but with the addition of a chlorination system. In this case the septic tank is normally a fiberglass container somewhere on the platform into which all toilet, kitchen, and laundry drains discharge. The usual settling and bacterial digestion takes place in this tank and the final effluent is chlorinated. OCS Order No. 8 requires that the effluent shall contain 50 ppm or less of biochemical oxygen demand (BOD), 150 ppm or less of suspended solids, and shall have a minimum chloride residual of 1.0 mg/l after a minimum retention time of fifteen minutes.

e. Workover Operations

Since petroleum production involves the handling of flammable fluids under pressure, the safety systems control is of utmost importance to preclude hazardous conditions. Nowhere is this hazard greater than during workover, or remedial operations on a well in order to improve its production rate or to replace faulty downhole equipment. Since workover operations are potentially hazardous, they must be planned carefully, both to keep wells from getting out of control and to prevent or minimize the release of oil to the environment. Currently under review within Geological Survey is a proposal to revise OCS Operating Order No. 8 to reduce or prohibit simultaneous production and drilling from the same platform. The restrictions will apply to workover operations as well as to drilling and production operations.

To reduce pollution, specially treated salt water that can be weighted with various materials is used for hydrostatic control when re-entering the wells in wire-line or swabbing operations.

To increase production, acid or other fluids and suspended particulate matter may be pumped through the well bore into producing formations. The function of this treatment is to enlarge flow channels leading to the well. The spent acid returns up the well when production is resumed, and is handled as are other fluids from the well. Oil and water contaminated with acid are disposed of ashore.

Sand produced along with the well fluids can cause the wells to plug, or "sand up", periodically and must be removed. Other procedures to increase productivity and oil recovery include the injection of high-pressure steam, water and/or gas into specially prepared injection wells. The water used for this purpose may be taken from the ocean or from formation water. Water too contaminated to be treated, and discharged is reinjected into formations, taking suitable precautions to ensure that fresh water aquifers will not be contaminated by oil or salt water. Gas produced from the well may be reinjected for pressure maintenance where feasible or piped to shore for sale.

From the safety standpoint, completion and workover operations must be conducted carefully, and it is their critical nature that, in all likelihood, makes these operations safer than they otherwise might be. Operators of swabbing and wire-line units are well aware of the hazard-

ous nature of their work and are extremely cautious. Despite the potential hazard, safety records during wire-line and swabbing unit work are excellent.

4. Transportation of Produced Oil and Gas

Since all of the proposed tracts which are expected to produced oil are near to presently producing areas, it is highly unlikely that any form of transportation other than pipeline will be used to move the produced gas and oil to the mainland.

Nearly all hydrocarbons produced on the OCS are transported by pipeline (as of 1971, only 3 1/2% of OCS crude oil was transported by barge). All natural gas, of course, must be moved by pipeline. A substantial amount of natural gas is necessary to justify economically the construction of a natural gas pipeline. In the early stages of the development of an oil field, small amounts of gas may be vented or flared or reinjected into the petroleum reservoir to maintain good pressure. However, wasteful venting or flaring is prohibited by OCS Order No. 11.

a. Construction and Burial

Pipelines laid offshore are constructed and laid by several different methods, depending mainly on the size, location, intended use, and cost. One method, pipepulling, involves the use of barges and tugs to pull sections of welded pipe from an onshore launchway over the preselected right-of-way. These sections may either be dragged along the bottom or suspended by floats. There are at least three limitations to this system. First, an extensive section of shore-

line, roughly perpendicular to the shore, must be available for the fabrication and launchway site. (Alternatively, it is possible although more costly to use a launching jetty constructed from the beach out over the water.) Second, the total length of pipeline that can be laid is limited. One company estimates the limit to be 100,000 feet for smaller diameter pipe. Third, the pipeline right-of-way must be essentially a straight line. The pipe pulling method is not used often for laying pipelines to OCS locations.

The second method, used in nearly all cases for large-diameter pipelines, involves the welding together of short sections of pipe on a barge while simultaneously moving the barge forward, and allowing the completed part of the pipeline to sag downward and lay on the seafloor. This operation begins at the offshore location and proceeds toward the intended onshore terminal. The advantage of this system is that the pipeline right-of-way need not be straight, and any diameter of pipeline can be laid in this way. The main disadvantage is the slow rate at which pipe laying proceeds; average rates are about 300-800 feet per day.

The third method has become increasingly popular in the last decade for laying smaller-diameter pipelines and involves the use of a lay-barge equipped with a large reel or spool of coiled pipe. With the reel-pipelaying technique, miles of pipe are welded together onshore and the appropriate coatings are applied. Then the pipe is wound onto a large diameter reel which is mounted on a barge or other floating vessel. The

vessel is then transported to the construction site. As the barge is towed along the right-of-way, the pipe is pulled off the reel through straightening equipment and continuous lengths of pipeline are laid on the seafloor. The reel method has several advantages. 1/ With no welding and little crane work being done on the barge, the operation is much less susceptible to interruption by bad weather and high seas. A thicker-walled pipe can be used, eliminating the necessity of a concrete coating for negative buoyancy, increasing the pressure rating, and adding significant corrosion allowance. This method allows pipelaying to proceed at a much faster rate than other methods - up to 5000-10,000 feet per day.

The reel method has two principal disadvantages. First, economic considerations limit the diameter of the pipe that can be laid to 12 inches. Second, during pipe-handling operations, pipe coatings are subject to occasional damage, necessitating repairs and thus, slowing the rate of pipelaying.

Pipelaying capabilities have now been extended to the point that 12 to 18 inches diameter lines can be installed in water depths exceeding 1000 feet. Connecting pipelines to seafloor facilities in water depths beyond diver effectiveness (about 1000 feet) will require remotely operated pipeline connectors. Some of these are now in various stages of development.

1/ Johnson, P. K., 1971. A reel-type pipelaying barge. Civ. Eng.-ASCE. October 1971: p. 45-47.

In depths under 200 feet present OCS administrative procedures requires burial of the pipelines. The minimum depth of burial is 3 ft. except in shipping fairways and anchorage areas, where the minimum depth is 10 ft. Burial is effected by jetting sediment away from underneath the pipeline and allowing it to sink into the resulting trench. The equipment used in this operation consists of a work barge equipped with high volume/high pressure water pumps and air compressors. From the barge, a multiple membered towline consisting of a strength member, water line, and air line extends downward to a U-shaped structure which straddles the pipelines and glides along it on rollers. Affixed to the U-shaped jetting device are several nozzles which direct water and air, under high pressure, ahead and below the pipeline. Sediments are blasted out of narrow trench by the water jets, partially lifted by the air and deflected to the sides by various types of fins. The suspended sediments fall diffusely along either side of the trench. As the jetting device is pulled forward, the pipeline settles into the trench and is partially buried quite soon by the reworked sediment as it slips and settles back into the depression. Complete burial and restoration of original bottom contours may require additional time. In shallow waters, experience has shown that contour restoration to be quite rapid, whereas in deeper waters, more than a year may be required.

Even though a buried line is protected from fluid forces it is not necessarily stable. 1/ If it is too light, it will gradually work its way up through the soil and become exposed to the water forces. If it

1/ Milz, E. A. and D. E. Broussard, 1972. Technical capabilities in offshore pipeline operations to maximize safety. Paper presented at 1972 Offshore Technology Conference, Dallas, Texas, May 1-3, 1972.

is too heavy, it will gradually sink in the soil and impose additional tensile stress in the line. Design procedures for determining the vertical stability of the line in sands and clays have been developed and are available in the industry.

Difficulties have been experienced in burying pipe in cohesionless sands. 1/ In this case the sand will often refill the jetted trench before the pipe can settle into it. Another method, fluidization of the sand, enables successful burial in this type of substrate.

In waters beyond the 200-foot contour, pipelines are not buried. Industry spokesmen maintain that as yet, burial in waters deeper than 200 feet is not economically feasible but that new equipment could be available in the future.

To prevent corrosion, pipelines are carefully coated with such materials as epoxy compounds or thick asphaltic mastic. If extra weight or mechanical protection is needed, these, in turn, are covered with a layer of dense concrete. The lines are protected from electrolysis by both impressed-current systems and by sacrificial anodes (zinc is commonly used). Corrosion prevention measures are now required by 49 CFR Part 195. Although offshore pipelines are relatively inaccessible as compared to onshore pipelines, they nonetheless can be repaired by divers. Experimental dives have been made to 1,000 feet, but work at this depth is difficult and expensive. Methods of using submersibles to latch on to a subsea line and repair it with mechanical arms and special tools are under study and nearing the point of practical demonstration.

1/ Ibid.

As in the case of workover operations, the expense of the pipeline installations, coupled with the catastrophic implications for the local marine environment should a major break occur, have combined to dictate a highly conservative design, emplacement, and operating philosophy.

As the pipeline construction approaches and traverses the shoreline, it is buried deep enough to avoid its being exposed by storm-associated beach erosion. From this point the pipeline construction will be extended toward a storage facility, wharf facility, or a major existing pipeline system, in turn leading to a processing facility, refinery, or interstate gas line.

b. Pipeline--Operation and Maintenance

The safe operation and maintenance of a pipeline system requires several redundant monitoring systems to ensure the integrity of the line and detect leaks. The primary leak detection system in use (required on all lines built after March 31, 1970 by 49 CFR Part 195.404 and 195.408) is a set of automatic pressure sensing recorders on both ends of each pipeline system. These recorders are equipped with a built in alarm system which either shuts down the flow automatically or sounds an alarm to alert personnel of an abnormal pressure level. In this way, a leak of substantial rate is detected immediately. This system is insensitive to leaks which do not produce a decrease in line pressure greater than 300-500 psi. It is essentially a safeguard to prevent the escape of large volumes of oil due to a catastrophic line break.

The second system of leak detection is the routine patrolling of the offshore wetlands routes by boat or aircraft, and onshore by wheeled vehicle or aircraft. A minimum patrolling frequency of intervals between inspections not exceeding 2 weeks is required by 49 CFR Part 195.412, but in actual practice is performed more often. This type of monitoring would result in the detection of all sizes of leaks of course, but would be of little consequence in preventing the loss of a large amount of petroleum in the event a large line were severed. The appeal of a system of regular pipeline patrolling is that it allows detection of small leaks and therefore complements the pressure-sensing system described above. With the present day volume of airborne and waterborne traffic over the oil producing area of the Gulf of Mexico, it is considered highly improbable that any spill would go undetected for any appreciable length of time.

The third system for leak detection consists of a series of volume-recording flow meters on either end of a pipeline system. Because nearly all crude oil moves from OCS areas to shore by common carrier lines, it must be metered in the offshore pipeline gathering system and again at the onshore pipeline terminal in order that each producer be properly credited for his share of the common stream. This flow monitoring system has been designed so that the flow sensors continually indicate net input and output in real time so that attendant personnel are able to discover a decrease in output and alert appropriate stations of the possibility of a leak.

One more safety feature which would be built into all pipelines resulting from this proposal, according to industry spokemen, is that remotely operated mainline block valves will be provided at remotely controlled pipeline facilities in order to allow isolation of segments of the pipeline. 1/ This is an industry standard and therefore "voluntary"; however, most companies operating pipelines subscribe to ANSI and would be expected to follow these recommendations. Table 46 shows the relationship between the diameter of a pipeline and the volume contained per mile of line.

Table 46. Length/Volume Relationship of Linepipe

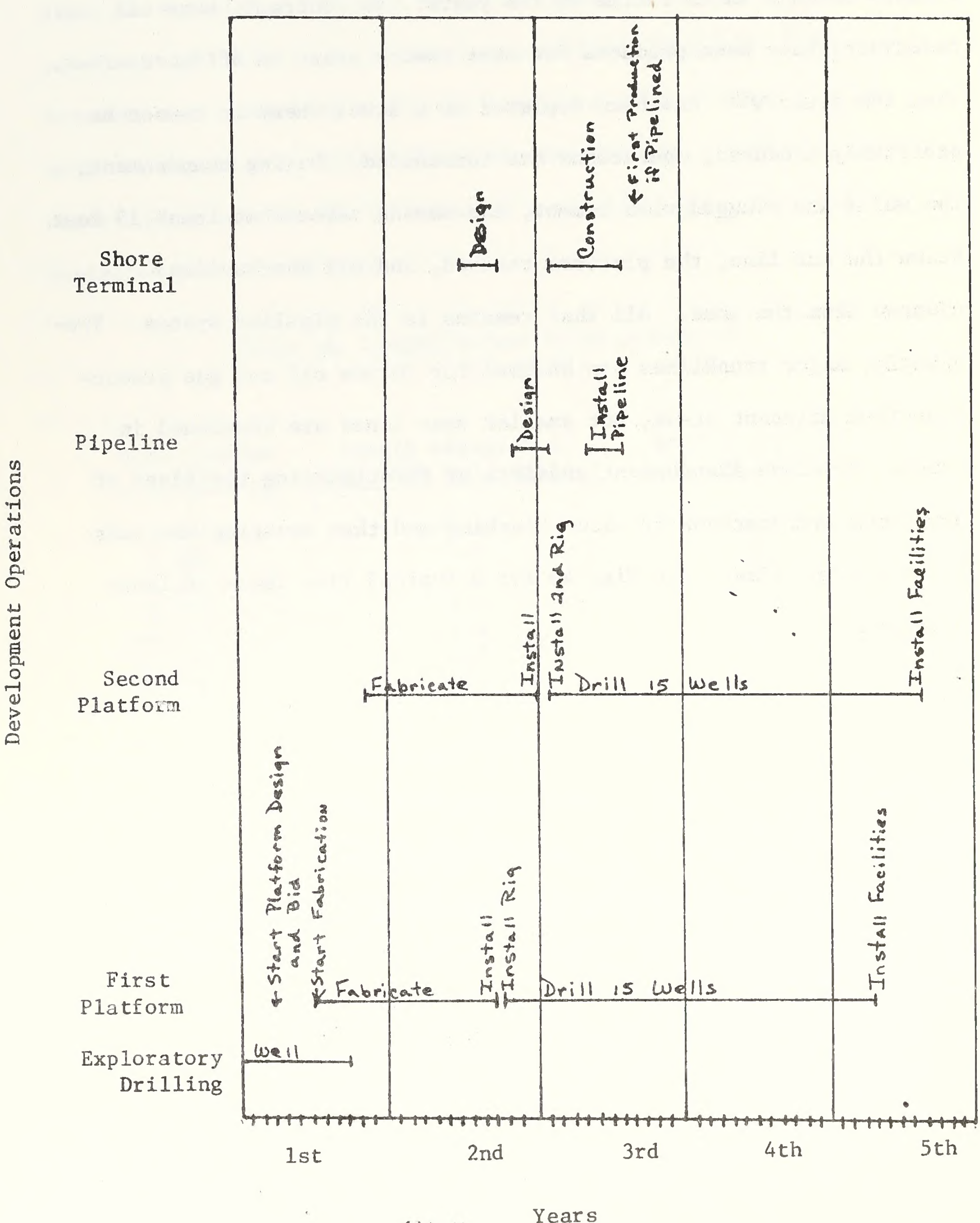
Size (inches ID)	Length Required to Hold 1000 bbl. (miles)	Barrels Per Mile of Line
2.067	45.6	22
4.026	12.0	83
6.026	5.3	189
8.071	3.0	334
10.020	1.9	515
12.090	1.3	750
24.000	0.3	2954

1/ American National Standard Liquid Petroleum Transportation Piping Systems ANSI B34.4-197 434.15, In-press.

5. Terminations of Offshore Oil and Gas Operations

According to industry estimates, with proper placement of wells and sufficient pipeline capacity, a gas reservoir could be profitably drained in as little as ten years. In contrast, some oil reservoirs have been produced for over twenty years in offshore areas. When the reservoir has been depleted to a level where it cannot be profitably produced, operations are terminated. During abandonment, the wells are plugged with cement, the casing severed at least 15 feet below the mud line, the platform removed, and all obstructions cleared from the area. All that remains is the pipeline system. Frequently, major trunklines can be used for future oil and gas production from adjacent areas, but smaller spur lines are abandoned in place. Pipeline abandonment consists of first purging the lines of entrained hydrocarbons by water flushing and then severing the ends below the mud line. See Fig. 49 for a typical time table of lease development.

Figure 49. Typical Time Table for Lease Development



B. General Environmental Impacts of Offshore Oil and Gas Operations

Introduction

The development and production activity following this proposed sale could result in a variety of impacts on the natural environment, on other Gulf of Mexico resource uses, on air and water quality, on land use patterns, on the social order, and on the economy. In the light of existing operating practices, regulations, economics, and technology, some impacts are the unavoidable result of routine operations and the probability of their occurrence is 1, or 100%. Other impact-producing events must be viewed as accidental, not a part of day-to-day operations, but caused by occasional human error or equipment failure. Still other impacts can be controlled or avoided by safe operating practices and by regulations.

This introductory section is devoted to setting the stage for the discussion of actual impacts by briefly describing impact-producing operations and events, and where possible, citing statistics and examples. Each subsection contains an estimate of the magnitude or extent or duration of impact which can be expected if the proposed lease sale is held. The reader is reminded that routine oil and gas operations are described in Sec. III.A.

1. Impacts Resulting From Day-to-Day Operations Which are Unavoidable Under Existing Operating Practices, Regulations, Economics and Technology

a. Discharge of Cleaned Drilling Muds and Drill Cuttings

The drilling mud and casing programs, and drill cuttings volume of a representative 10,000-foot offshore well were

discussed in Sec. III.A.3.b. Most production on the Louisiana OCS comes from formations in the depth range of 8,000-12,000 feet. Many wells resulting from the proposed leasing could be drilled and produced within this depth range. Drilling wells to the maximum 10,000 feet depth would require approximately 7,000 bbl. of seawater drilling muds containing almost 300 long tons of commercial mud components mixed with seawater. The volume of cuttings generated by the 10,000 foot well was shown in Table 43.

During the course of drilling this representative 10,000-foot well, almost 200 tons of commercial mud components and almost 900 tons of drill cuttings will be discharged overboard.

The Geological Survey has estimated that between 700 and 900 wells would be required to develop the proposed acreage. At this time it would be premature to narrow the range of possible wells or predict the numbers of wells drilled to around 10,000 feet and those drilled to deeper or to lesser depths. Therefore, in order to predict the total quantity of drill cuttings and muds discharged as a result of this sale, it will be necessary to consider the entire range of from 700 to 900 wells drilled at 10,000 feet. The reader should bear in mind that the real figure is probably somewhere near the middle.

The drilling of 700 5,000 foot wells would result in the discharge of 270,000 tons of drill cuttings and 30,000 tons of commercial mud components; whereas 900 15,000 foot wells would discharge 765,000 tons of drill cuttings and 380,000 tons of commercial mud chemical.

Drill cuttings are, of course, composed of shattered and pulverized sediment and underlying native rock. In considering impact, it is also relevant to examine those components of the drilling mud which will be discharged. The following table (Table 46) briefly identifies these components. The reader should bear in mind that this discussion is based on the representative well drilling mud program used in Sec. III.A.3.b. and other compounds, listed in Table 44 of that section, could be added in special cases.

The Environmental Protection Agency view is that drilling muds must be considered harmful and are subject to EPA permitting procedures and effluent limitations.

b. Discharge of Produced Formation Water

There is no geological evidence on which the amount of formation waters produced from wells resulting from this proposal can

Table 46. COMPONENTS OF DRILLING MUDS WHICH ARE NORMALLY DISCHARGED INTO THE SEA

Substance	Source	Use	Composition	Known Hazard
Attapulgite clay	Quarry	To cause gelling of salt water based muds	A light green magnesium-rich clay, quarried as "Fullers Earth"	NONE
Bentonite Clay	Quarry	To cause gelling of freshwater based muds	A light-colored montmorillonitic clay; slippery sticky when wet; swells to 10-20 times its dry volume	NONE
Caustic soda	Electrolysis of sodium chloride brine	For pH control	Sodium hydroxide, NaOH	Corrosive in concentrated form; not harmful after mixing into mud at low concentration and allowed to react
Ferrochrome lignosulfonate	Digestion of wood by sulfonate process; removal of cellulose; reaction with chromium compounds	Dispersant and emulsifier	Ferrochrome salt of lignosulfonic acid; content: Fe-2.6%, Cr-3.0%, S-5.5%	Possible chromium toxicity in pure form, none known from diluted form in muds
Organic polymer	Chemical process with plant starch, wood fiber as raw materials	Conditioner, texturizer	Starch, cellulosic derivatives	NONE
Proprietary defoamer	Soap making process.	Defoamer	Aluminum stearate Al $[CH_3 (CH_2) 16] 3$	NONE

be predicted. Several years ago an estimate was made that all producing OCS wells offshore Louisiana (about 3,500) produced 240,000 bbl. per day of formation water. A recent check showed that the Florida Jay Field, just north of the western part of the area included in this proposal, produced very little water at all. It is well known that some hydrocarbon reservoirs contain substantial amounts of water, whereas others contain almost none. Therefore, no predictions will be made at this time concerning the amount of formation water production which may be expected. While substantial amounts will likely be discharged into the sea, a significant proportion will also be reinjected into subsurface formations.

The mineral content of formation waters also cannot be predicted. Some fields in Texas produce almost pure water whereas, one field in Michigan produced brines containing 624,798 ppm mineral salts. The average total dissolved solids of 76 samples from southern Louisiana and the Outer Continental Shelf was found to be 112,513 milligrams per liter (mg/1) with a high of 270,400 mg/1 and low of 61,552 mg/1. They commonly contain varying amounts of iron, calcium, magnesium, sodium, bicarbonates, sulphate, and chloride, with sodium and chloride being the most abundant ions. For informative purposes, refer to table 45 which shows the content of three representative brines (formation water) from offshore Louisiana. They are classed as formation waters containing (1) high solids, (2) average solids, (3) low solids.

In addition to water quality degradation from high mineral content and low dissolved oxygen, a very small amount of oil is entrained in formation waters which are discharged into the sea. OCS operating orders require that the average oil content at the point of discharge must not average more than 50 ppm. EPA is presently developing effluent limitations for discharges from production platforms which will be based on technological feasibility. OCS operations will be subject to these limitations.

The MIT Offshore Oil Task Group (MIT, 1973) has estimated that biologically, this could be the most significant of all minor discharges, for this oil could contain a high percentage of water soluble aromatics. They note, however, that there appears to be no data on the fractional composition of the oil remaining in the water after treatment in the oil/water separators. The separation process is ineffective against that portion of the oil which is dissolved into the water.

c. Disposal of Solid Waste and Sewage

See Sec. III.A.3.e. for a description of source, content, treatment, and disposition. No prediction of volume or potential impact will be made at this time.

d. Disruption of Sea Floor and Resuspension of Sediments During Pipeline Burial

See Sec. III.A.4.a. for a description of this operation. During pipeline burial, a large volume of sediment is dis-

rupted and resuspended for a short time in the overlying water. Unfortunately, it is impossible to calculate a reasonably accurate volume of material that is reworked because the width of the trench varies greatly with compactness and the fluidization point of the sediment. A very rough estimate of the trench dimensions is 5 feet deep by 6 to 12 feet wide. Assuming a parabolic cross-section, approximately 4,000-8,000 cubic yards per mile would be disrupted, some of which would be resuspended. This figure cannot be applied to Geological Survey's prediction of 1300 miles of pipeline resulting from this sale because some of that milage includes sections in water deeper than 200 feet, where burial is not now required, sections of the gathering systems around groups of platforms where burial may not be required, section in State waters where the Department has no jurisdiction and cannot require burial, and sections laid onshore. At some future date, when exact pipeline routes are drawn, our figure may be used as a multiplier to determine the total volume of sediments disturbed.

e. Digging of Trenches and "Push-ditches"

The volume of material reworked is of little concern here; instead, the width of upland or wetland disturbed and devegetated is of importance. Our rough estimate is that perhaps 50 to 60 feet of land will be extensively driven over by construction and burial equipment, resulting in some damage to vegetation and compaction of soil in vehicle tracks. Actual disturbance of soil and complete removal of vegetation will occur in a band of perhaps 30 to 40 feet. At this

time we do not know how many miles of pipeline will be buried onshore through wetlands or elevated terrain. The establishment of pipeline corridors is considered in Sec. V. C.

f. <u>Placement of Temporary and Permanent Platforms, Boats, Barges, and Pipelines in Conflict with Commercial Fishery Trawling Operations and Ship Navigation</u>

As a result of this proposed sale, Geological Survey estimates between 100 and 200 platforms will be placed in this area. As discussed in section IV. D., there are four factors that will affect the commercial fishing in this area. These are (1) the removal of sea floor from use by trawlers, (2) the creation of obstructions on the sea floor that cause damage to trawling nets, (3) the possible contamination of catch by oil, and (4) direct lethal or sublethal effects on fish.

Ship traffic will not increase as a result of this sale thus the only additional hazard will be the addition of incremental structures in the area. Previous records of ships colliding with platforms is discussed in section IV.A.2.d.

Geological Survey also predicts an additional 1300 miles of pipeline in the proposed area. Because of the administrative procedures concerning the burial of common carrier pipelines in water depths less than 200 feet, no adverse affects are predicted. It should be noted that 128 of the proposed 295 tracts lie partly or completely beyond the 200 foot contour.

g. Placement of Structures, Pipeline Burial Cuts, Ancillary Onshore Facilities Where They May Degrade the Scenic Values of the Area

As stated in section IV.H.2., and 78 of the 295 proposed tracts lie within 17 miles of the shoreline which means that some portion of a 100 foot structure constructed on one of those tracts could be visible from the mainland shoreline or one of the barrier islands. The probability that permanent platforms will be erected on each tract, based on past exploration success rate, is about 35%. This is to say that approximately 1 out of every 3 tracts offered for lease will eventually require the erection of platforms for its development. It is estimated that each full tract (5,760 acres) developed will average two structures per tract.

Ancillary onshore facilities will be constructed where the pipelines come ashore. These facilities will require approximately 40 acres each for construction and operation. And, as estimated in section IV.H.2., the negative impact on the aesthetic values of the pipeline burial cuts will diminish in about a year.

2. Impacts Resulting from Accidents

In any complex industrial operation involving heavy equipment, flammable materials, work at sea, large numbers of employees, and a large-scale reliance on complex technology, it is inevitable that accidents will occur. Thus, although theoretically avoidable, impacts resulting from accidents can be viewed as unavoidable in a statistical

sense. It has been possible to gather data and derive statistical frequencies for some of these events, which are presented below. An attempt has also been made to predict the number and magnitude of impact producing events which will result if this proposed sale is conducted.

a. Natural Gas Leaks Associated with Blowouts

Information furnished by the Geological Survey for the period 1956-1973 lists 38 gas leaks associated with well blowouts during OCS oil and gas operations in the Gulf of Mexico. Eleven of these incidents involved fires and five were associated with oil or condensate spills. The duration of the blowouts ranged from two hours to over seven months. Several incidents resulted in the injury and death or members of the crew, and damage or loss of valuable equipment. Environmental damage has never been observed to result from natural gas blowouts and no estimates of the amount of gas lost have been made.

b. Oil Spills Greater Than 50 Barrels in Size

Note that we do not entitle this section "Major" or "Massive" or "Large" etc. Several governmental agencies have endeavored to establish a system for oil spill size classification, i.e., the U.S. Coast Guard, U.S. Geological Survey, Environmental Protection Agency. Because these classification systems are not similar, we choose not to adopt any of them, but instead, we believe any spill of 50 bbl. or more is significant enough to receive individual consideration. Data supplied by the Geological Survey for the period 1964-1973

indicate a total of 43 oil spill incidents connected with Federal OCS oil and gas operations in the Gulf of Mexico involving 50 bbl. or more of oil and condensate.

The estimated total volume of oil spilled during this period as a result of these incidents is slightly more than 300,000 bbl. A distribution of these 43 incidents as to type and amount spilled is presented in Fig. 50.

In the following discussion of oil spills by type, several predictions will be made by comparing the volumes of these spills and the total production of oil and condensate during the same period, 2.8 billion bbl.

(1) Pipeline Accidents

During OCS operations, more oil has been spilled from pipeline accidents than from all other sources combined. In October of 1967, a vessel underway during a storm and with its anchor inadvertently left out, snagged and severed a pipeline about 20 miles west of the mouth of Southwest Pass, Mississippi River Delta, Louisiana. The resulting spill went undetected for nearly two weeks, releasing over 160,000 bbl. of oil into the sea. In March of 1968, another anchor/pipeline accident resulted in a 6,000 bbl. spill. In February of 1969, a pipeline leak released over 7,500 bbl. into the sea; the cause was never determined.

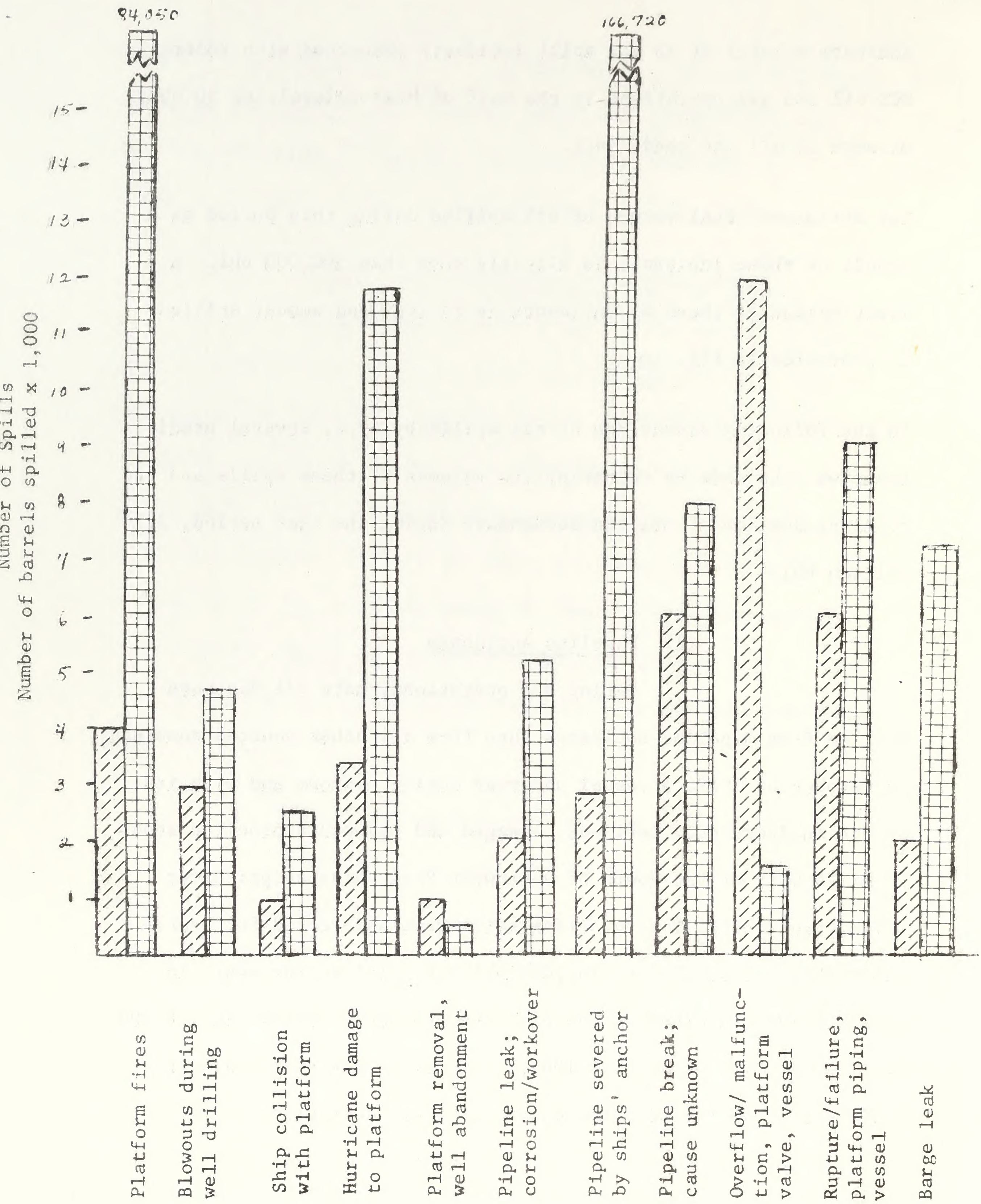


Figure 50. Oil Spills ≥ 50 bbl. Number and Amount (Data from Geological Survey.)

Number of Spills ▦ Amount of oil Spilled ▨

Beginning in 1969, several actions were undertaken to decrease this inordinately high volume of spillage per accident and to keep the frequency of occurrence low. Since 1969, the Bureau of Land Management, through administrative procedures, has required the burial of all new common carrier pipelines with a minimum of three feet of cover out to a water depth of 200 feet. Where the pipelines cross shipping fairways and anchorage areas, they must be buried at least 10 feet deep. The 10-foot burial in anchorage areas and shipping fairways is a U.S. Army Corps of Engineers requirements. The New Orleans District Office, Permit Branch, of the Corps reported that conventional jetting is used to bury pipe in soft bottoms, and a hydraulic dredge is used in harder bottoms. An inspector from the Corps is occasionally present during trenching operations; otherwise, verification is made by reviewing the pipe-laying "as-built" plans. In water depths of less than 200 feet, only the lines in the gathering system between adjacent platforms of a particular oil or gas field may remain unburied. Permits to construct such lines are granted by the Geological Survey and the decision to bury is made on a case-by-case basis.

In connection with regulations formulated by the Office of Pipeline Safety (OPS), Department of Transportation (49 CFR Parts 192 and 195) offshore pipelines were required to be coated with tightly bonded, moisture impervious materials, followed in many cases by a layer of

dense concrete for mechanical and corrosion protection. In addition to coatings, impressed currents or sacrificial anodes were required to protect against electrolytic corrosion. The OPS regulations also require continuous line pressure monitoring with some type of communication system (a built-in alarm or automatic shut-down system is normally used), and regular inspection of the pipeline route for leaks and other irregularities.

Other features used by industry also serve to mitigate against accidents: continuous metering systems, automatic high pressure shutdowns, and remotely controlled mainline block valves that can isolate sections of a line. A more complete discussion of all of these systems is presented in Sec. III.A.

Caution should be inserted at this point. In established oil and gas fields where older lines are present, corrosion will be in a more advanced state, the line may be poorly buried if at all, and all of the above-mentioned requirements for safety and control features may not apply. In fact, industry spokesmen have estimated that 48% of all pipeline leaks occur in lines that have been in use for 15 years or more.

With all of the above information in hand, it is our conclusion that leaks of the magnitude of thousands of barrels, such as those cited from 1967-69, could not occur from any lines resulting from this proposal, providing that existing regulations are stringently enforced

and inspection procedures diligently followed. As evidence, we note that from 1970 to the present time, there have been five recorded pipeline leaks on the Gulf of Mexico OCS, resulting in a total spillage of 5,300 bbl. of oil, 5,000 of which was due to internal corrosion of a pipeline.

For the purpose of predicting the rate and size of pipeline oil spills offshore that could result from this proposed lease sale we have made the following assumptions:

- All new common carrier pipelines will be routed on the basis of State and Federal coordinating measures (see V.C.).
- The industry will make a sincere effort to comply with existing codes and regulations.
- There are no identifiable geologic or other hazards which would lead to pipeline damage more often or severe than the levels experienced off Louisiana and Texas.

Based on these assumptions, we predict that not more than 300 bbl. per year will be spilled due to pipeline related accidents, and we predict that the maximum size of any one spill will not exceed 3,000 bbl.

The latest pipelaying and monitoring techniques combined with modern materials and equipment should insure that the 1,300 miles of pipeline required for this sale suffer no major breaks for several years to come. Strictly on a judgment basis and with no reference to

existing statistics, it is estimated that pipelines breaks may range from zero in the early years to 3 incidents per year in later (±20) years.

(2) Oil and/or Gas Well Blowouts During Drilling

The control of imminent blowouts by increasing mud weight and activation of blowout preventers is discussed in Sec. III.A. In the event the control systems fail, however, the well will blow out of control, and if it is an oil well, it will release large quantities of oil into the environment. If a gas well blows out, the escaping gas either burns or is dissipated in the atmosphere.

One example of a blowout during well drilling is the Santa Barbara incident.

SANTA BARBARA SPILL 1/

On January 28, 1969, a blowout occurred below Union Oil Company's fixed drilling platform A in the Santa Barbara Channel, about six miles southeast of Santa Barbara, California. This blowout and spill occurred through a pre-existing fault in the ocean floor adjacent to the well after gas under high pressure from a deep reservoir was accidentally injected into shallow reservoir sands. The resulting build-up of pressure in the shallow reservoir sands

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1/ Straughan and Kolpack (1971).

soon exceeded the strength of the overlying rock layer and caused a rupture to occur. The rupture formed a fissure zone, thus opening an avenue of communication between the hydrocarbon reservoir and the seabottom (Reinhart, 1970).

Total initial spillage was estimated by the Geological Survey to be 10,000 bbl., with subsequent leakage amounting to about 8,500 bbl. Other estimates of spillage range from 70,000 to 700,000 bbl. 1/

This is certainly a very tenuous base for statistics, but the numbers indicate one blowout per 3,900 wells drilled or .026% of wells drilled blew out, spilling an average of 2,100 bbl. of oil per blowout. Using the average between the maximum and minimum number of wells estimated to be required for this proposed sale (900-700), the probability for a polluting blowout occurring at all is $\frac{800}{3900}$ or 0.21. If there is no blowout, there is then of course, no oil spilled. Should a blowout occur, the volume of oil that might be spilled is impossible to estimate; the historical average, as indicated above, is 2,100 bbl. per blowout.

(3) <u>Oil Spills Resulting from Platform Fires</u>

Platform fires can be ignited by a variety of events. Most are undoubtedly caused by combustible hydrocarbon liquids or vapors being brought into contact with arcing electrical

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1/ Testimony of Dr. Carl H. Oppenheimer, OCS Public Hearing of August 23, 1972, New Orleans, Louisiana.

devices and overheated mechanical devices; more rarely they could be ignited by lightning or static electricity. Sometimes, platform fires first involve the accidental ignition of fuel, solvent, or heat exchanger fluids. If caught soon enough, these small fires are usually controllable, but once a storage tank or well catches on fire, major structural damage occurs and adjacent producing wells on the platform may have their piping severed and also contribute to the fire. It is for this reason that we have chosen to group accidents of admittedly diverse causes under the heading "platform fires". By far, the vast majority of fires are extinguished quickly, before serious damage is done. But once a fire burns out of control, it usually leads to damage of the well heads and multiple well involvement. As was stated in Sec. III.A. downhole safety shut-in devices have a poor record of performance to date.

If producing wells are damaged in a way that allows them to flow freely and be ignited, they are usually allowed to burn while operations are underway to control the wild wells from a remote location. In this way, a high percentage of the hydrocarbon liquid expelled by the well is burned. This in turn results in less fire hazard from floating oil near control operations such as relief well drilling and in lower levels of ocean pollution. If a blowing well is releasing mostly or entirely natural gas,

the possibility of ocean pollution is minimal. However, the safety of personnel and the security of the platform or drilling structure are imperiled during a fire. The decision whether or not to extinguish a gas fire depends on the circumstances of the moment. For example, it might be advisable to allow a gas well fire to burn while remedial action is being taken, as long as the structure and personnel are not in jeopardy. This would preclude accidental ignition while personnel were in the area of gas accumulation. The overall thrust, however, is to extinguish the fire quickly and bring the well under control.

An example of an apparently spontaneous platform fire which resulted in the ignition of several producing wells and extensive damage to the platform is the Chevron Fire of 1970. 1/

On February 10, 1970, fire was observed on Platform "C" shortly after midnight from an adjacent platform. Platform "C" is located in 40 feet of water about 75 miles southeast of New Orleans, Louisiana. Field personnel boarded the burning platform but had to evacuate immediately because of the intense heat. During the following month, planning, construction and assembly of equipment for extinguishing the fire and controlling the anticipated oil spill was carried out. From March 10 through March 31, several methods were successfully used to control six

1/ U.S. Dept. of Interior (1970).

of the seven wild wells on the platform (one well sanded up and plugged itself). These included dynamite, relief well drilling, wellhead repair, weighting and sealing chemicals, and activation of downhole safety valves.

Reliable estimates placed the total volume of oil spilled at about 30,000 barrels. Oil from the spill was a light crude, containing a high proportion of lower boiling constituents and a relatively low concentration (about 10%) of aromatic hydrocarbons. Through a fortunate set of circumstances, the oil was sprayed high into the air under great pressure and frequently into considerable wind, so that far more evaporation took place than usually occurs during a spill. Samples collected 500 feet from the platform and analyzed by Federal Water Quality Administration (FWQA) laboratories showed a loss in volume of 16%, all in the lighter ends. Also, about 5,000 bbl. of oil were removed by skimming. Some 1,500 bbl. of chemical emulsifier were used during the spill as well.

Accidents caused by human error during routine rework, maintenance and repair have resulted in at least two large spills of oil, along with destruction of platforms, the loss of a work vessel and several human lives. On May 28, 1970, renovation and repair work was being carried out on a platform in Galveston Block 189-L, offshore Texas. The platform had been shut-down and workmen were sand-blasting, painting, torch-cutting, and welding. When

welding was attempted on a line leading to a storage tank containing 2,000 bbl. of crude oil, a series of explosions occurred, resulting in the death of five workmen and injuries to six. Burning oil spilled onto a nearby service boat, nearly destroying it, and about 100 bbl. also reached shore, polluting Galveston beaches. (National Transportation Safety Board, 1970).

The Bay Marchand Fire (Shell Fire and Spill) of 1970-71 was ignited as a result of human error. The plastic coating in the tubing of one well sloughed off and plugged the tubing. During cleaning operations, workmen failed to close well control valves completely for a brief period while the well was left unattended. Plastic, used as a corrosion preventive in the tubing of well B-12, had sloughed off and lodged in the gate of the master valve. As the gate was closed, this plastic compressed, preventing complete closure of the valve, but giving an indication that the valve was closed. The well appeared to be shut-in, but after 30-40 minutes the plastic began to slip through the gate opening and was finally released, thus opening the well to the atmosphere and allowing oil to escape.

Falling debris and intense heat from the resulting ignition and fire damaged ten of the other 21 wells on the platform; thus 11 wells in all were contributing hydrocarbon to the fire. Four

workmen died immediately and 36 were hospitalized. After five months the last blowing well was capped (Berry, 1972; Nelson, 1972). An undetermined amount of petroleum was consumed by the fire and 53,000 bbl. spilled into the sea. 1/

During the history of OCS production there have been many fires of varying sizes. Most have been extinguished before serious damage and pollution occurred. Of 81 recorded explosions and fires, only four have resulted in pollution of the sea by oil. However, the volume spilled, an estimated 84,050 bbl. is significant. Of even greater significance is the unfortunate injury of 120 men and death of an additional 59 (as listed in Geological Survey records).

For the purpose of predicting platform fire-related pollution that could result from this proposal, the incompleteness of the existing data on number of producing oil wells and number of platforms requires that we consider instead, the relationship between pollution and total oil production. The following assumption is made:

- hazards leading to platform fires and technology used to control fires and blowing wells for the present proposal will not be significantly different from those present in operations in the western Gulf.

1/ EPA estimates, based on remote sensing surveys, are about double the 53,000 bbl. estimate of the Geological Survey.

It is significant that OCS orders now require all new OCS completions (with shut-in tubing pressure less than 4 000 psig) to be protected with surface actuated subsurface safety devices, thus eliminating blowouts due to faulty and/or sand cut veolicty-actuated downhole safety devices. OCS Order No. 5 also requires that wells with shut-in tubing pressures greater than 4,000 psig shall be protected with a subsurface controlled subsurface safety device.

During the years 1964-73, total oil and condensate production from the OCS Gulf of Mexico amounted to about 2.8 billion bbl. During that same period Geological Survey accident records indicate four incidents of platform fire-related pollution resulting in a spillage of 84,050 bbl. This amounts to a spillage rate of 0.003%. If we apply this to the maximum projected production rate for this proposal (up to 125,000 bbl./day or 45,625,000 bbl./year) 1,370 bbl. per year of spillage may be predicted by this method of calculation. Based on the above assumption, we conclude that the maximum size of a single spill in the future most probably would be limited to the volume of flammable material in storage on the platform at the time the fire started.

(4) Pollution Caused by Hurricanes

Whereas damage and subsequent pollution caused by the passing of a hurricane is not an accident in the

strictest sense, lack of adequate preparation for the onslaught of a hurricane can be viewed as an avoidable "accident". The only availabe data on the impact of hurricanes to pipelines is Blumberg's report of 1964. According to his study, buried pipelines received no damage from either Hurricane Carla, 1961 or Flora, 1963.

Accident records for the Gulf of Mexico OCS indicate that on October 3, 1964, a hurricane passed over the water off central Louisiana and destroyed three platforms, resulting in the spillage of almost 11,900 bbl. of oil. All of the oil was lost from tanks on the platforms used to store produced oil prior to transshipment by barge.

Since 1964, three major hurricanes have hit the east half of offshore Louisiana where extensive offshore petroleum production takes place. While causing financial damage to the offshore oil industry, they have not resulted in major pollution incidents from operations in Federal waters, although smaller scale incidents have occurred. The threat of significant damage and major pollution incidents caused by hurricanes should not be discounted, however. The latest of these was Hurricane Camille. On August 17, 1969, she passed along the eastern flank of the

Mississippi delta of Louisiana and into the Mississippi Gulf Coast. 1/ Camille's top winds were estimated at 201.5 miles per hour, and the barometric pressure in he calm eye dropped as low as 26.61 inches of mercury. The hurricane surge at Pass Christian, Mississippi, was recorded at 22.6 feet above the normal level of the Gulf. Offshore installations in areas near South Pass, Main Pass, and Breton Sound were badly damaged. Prior to arrival of the storm, the Offshore Operators Committee advised tapering off production operations, and before the storm hit, 4,000 wells in state and Federal waters were shut-in and 3,000 workmen evacuated. Because of this caution, no injuries to petroleum production personnel were reported and there was a total absence of blowing wells and few leaking wells. The U.S. Geological Survey reported no oil slicks in Federal waters and only one in State waters.

During the onslaught of Camille, one production platform was destroyed and two were damaged, two drilling rigs were destroyed, and three were damaged. Also in the area were seven drilling rigs that were not damaged.

When the Weather Bureau advises that a hurricane or serious tropical storm is imminent, all oil and gas facilities in or adjacent to the path of the storm are evacuated. Upon evacuation,

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1/ Corps of Engineers, Report on Hurricane Camille, Report No. 1338, 1970, U.S. Army Engineer District, New Orleans, Louisiana.

all surface equipment and wellhead controls are shut-in. In addition, blank tubing plugs are set in as many wells as possible to further reduce the possibility of pollution in the event the well is damaged. These tubing plugs form a seal against fluid flow.

Thus, it can be seen from accident records and industry performance that pollution due to hurricanes has resulted not from damaged and wild wells, but from platforms where the product transportation mode has been by barge. Because it is anticipated that only a relatively small amount, if any, of oil will be barged (i.e., 2% of all OCS oil is barged and almost all new production is conveyed by pipeline) we do not feel there will be any substantial spills as a result of hurricanes.

Based on the total oil and condensate produced during the years 1964-73, (2.8 billion bbl.), we note that 11,900 bbl. represents a spillage rate of 0.00043% due to hurricane damage. Projecting this rate to the maximum annual production rate projected for the proposed sale, we note that almost 200 bbl. per year could be spilled during hurricanes. This prediction assumes the incidence of hurricanes to be uniform through the Gulf of Mexico OCS (i.e., about 1-3 per year). The maximum spillage from a single hurricane would depend on the extent of barging (and therefore,

the number of platforms with large storage tanks) and volume of oil present in the tanks. With only one incident on record, no generalization can be made concerning the maximum spillage during a single hurricane.

(5) Accidental Spills from Overflow, Malfunction, Rupture or Failure of Platform Piping Valve or Vessel

This category of spills is essentially an extension of the "minor" spills, i.e., it includes those spills of the same origin as minor spills but consists of those that involved the loss of 50 bbl. or more before the condition was corrected. Accident records indicate a total of 12 such spills through 1973. Total spillage was 1,558 bbl. or an average of 130 bbl. per spill.

Assuming conditions leading to such spills will remain the same in the future, the spillage rate of 1,558 bbl. to 2.8 billion bbl. produced is 0.00006%. Projecting this to the maximum level of production for this proposal (45,625,000 bbl./yr.), the predicted spillage is a little more than 27 bbl. per year. In the past, the maximum size of such a spill has been about 400 bbl.

(6) Accidental Spills Due to Ships Colliding With Platforms

To be considered here are spills that occur from platforms resulting from a collision by a commercial vessel. Spills of OCS produced oil from tankers and barges is considered in the next section (7). Consideration of vessel damage, platform damage, loss of life, and economic loss is included in subsection d., below.

In April of 1964, a freighter off central Louisiana struck and damaged a platform, resulting in a fire and the loss of 2,560 bbl. of oil into the sea. Accident records do not indicate a blowing well, therefore, the source of oil was probably a large storage tank, used to accumulate production for barge transshipment.

Again using data for spillage vs. production, we estimate that 42 bbl. per year could be spilled from accidents of this type. The maximum size of a single accident is difficult to predict. A history of one accident is obviously insufficient for generalization.

(7) Tanker and Tank Barge Accidents and Operations

Almost 36.5 million barrels of oil are released annually to the marine environment as a result of accidents, carelessness or mismanagement (Charter, et. al., 1973). Figure 51 shows the percentage of the total outflow from various

polluting sources for the entire world oceans (Porricelli and Keith, in press). Figure 52 further breaks down the data on 269 polluting incidents which occurred in 1969 and 1970 involving tankers. This data puts into perspective the amount of pollution from tank barges and tankers, and shows, to some extent, the amount of spilled oil attributable to various types of tanker accidents.

In 1971, the United States tanker fleet carried 5.5%, or 71 million metric tons, of all waterborne petroleum in the world. In the same year, they were responsible for discharge of 55,000 tons of oil into the marine environment which means that on the average .08% of each cargo was spilled as a result of tanker casualties and operations. Porricelli (1969) states that .03% of each cargo by U.S. tank barges is spilled into the marine environment each year as a result of mishaps and operations. These two figures can be used to calculate the potential amount of oil from this proposed lease sale that will reach the marine environment as a result of tanker and tank barge movement of oil.

Figure 51. Sources of Oil Pollution to the Oceans from Porricelli and Keith, in press

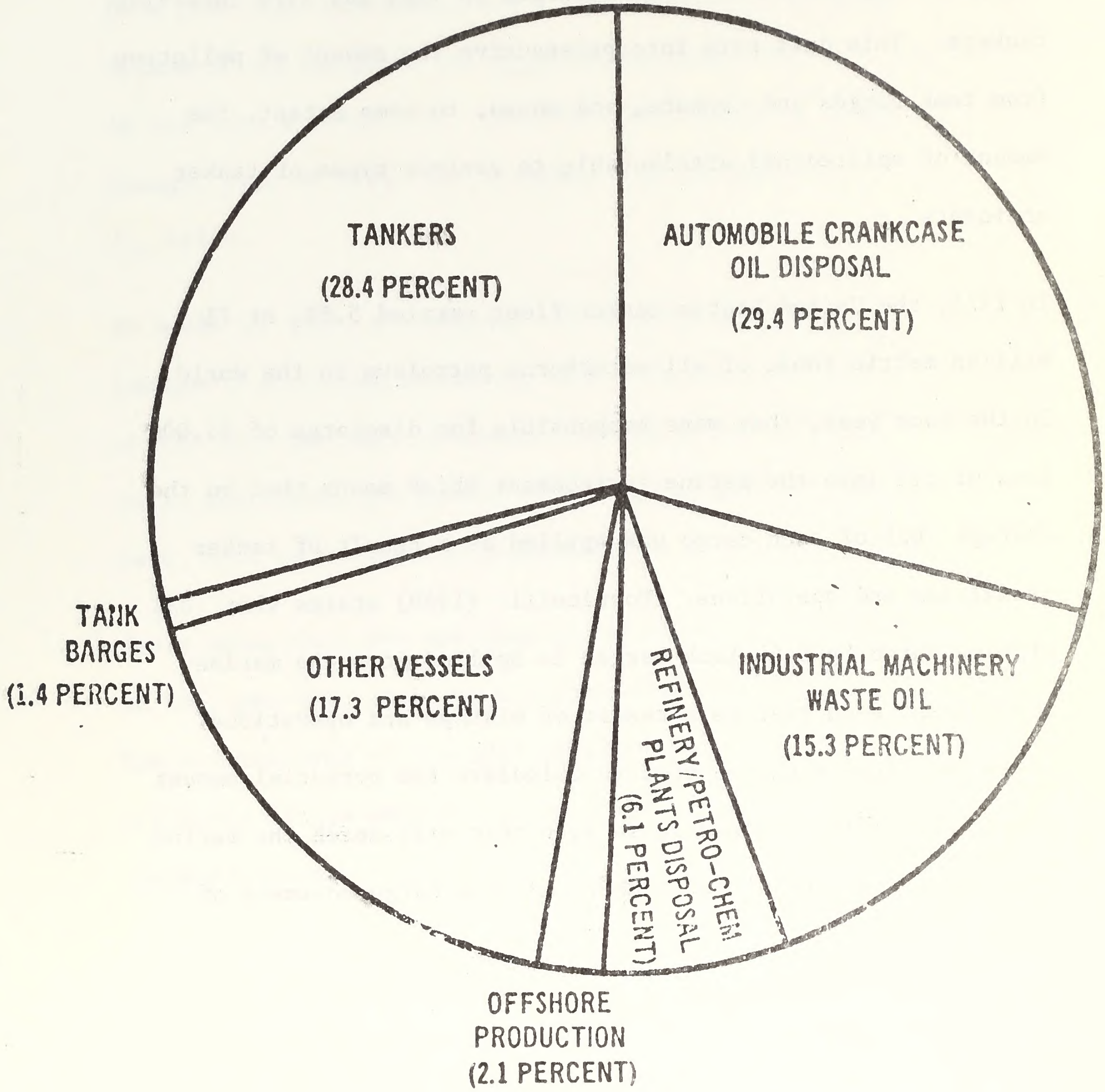
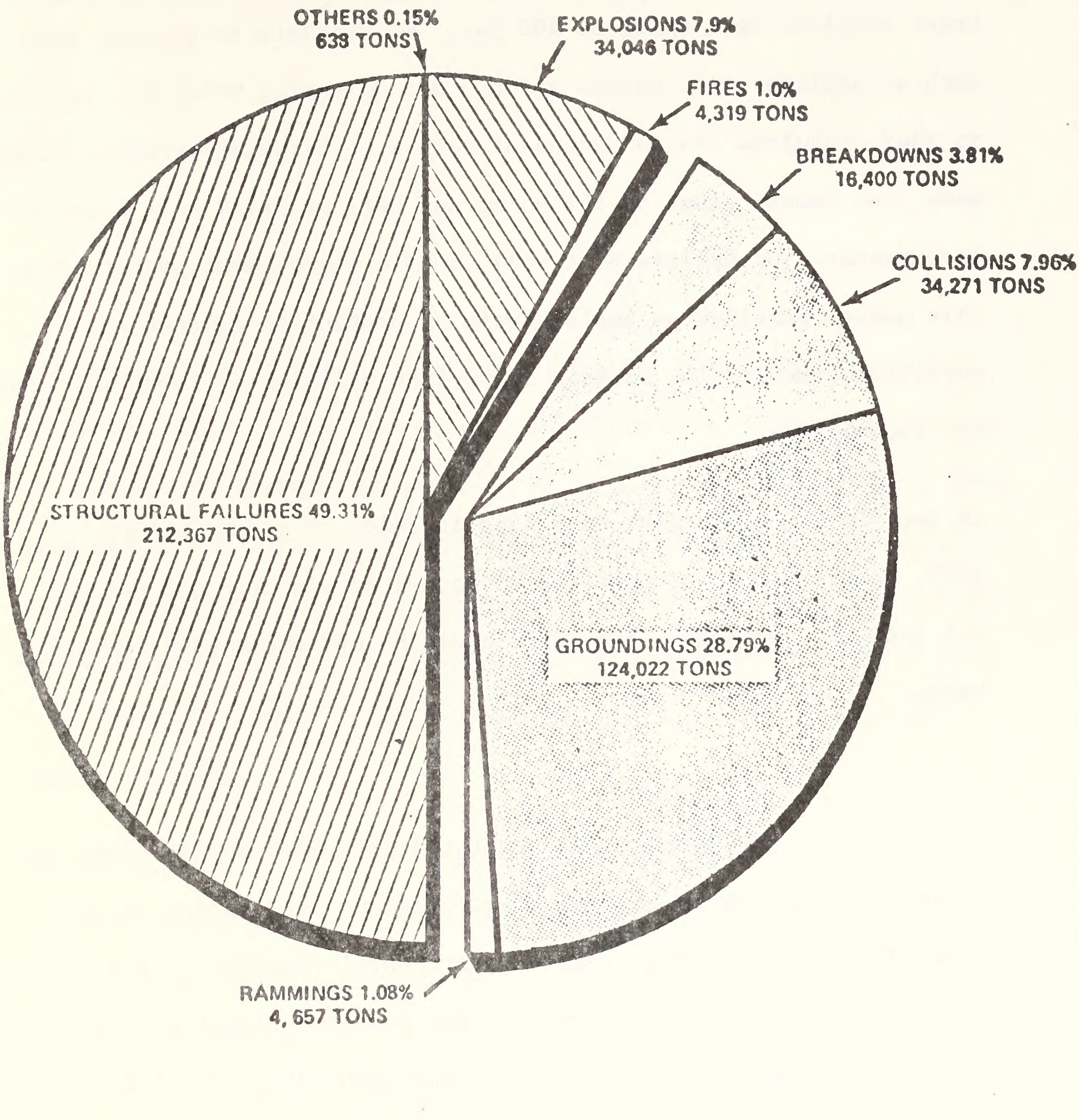


Figure 52. 1969-1970 Tanker Polluting Incidents, Percentage Oil Outflow by Type of Accident from Porricelli and Keith, in press



(8) Other Spills of 50 Barrels or More

Just two recorded spills remain which do not fit into the categories used in the preceding subsections.

In June, 1965, during well abandonment and platform removal, a well break resulted in a spill of 500 bbl. We hesitate to predict that such an accident will happen again. OCS Operating Order No. 3, issued in 1969, requires that a redundant series of bridging devices, weighted muds, and cement plugs be placed in any well or drill hole prior to abandonment. We believe that well or hole abandonment performed in this manner provides an ample margin of protection against any possible communication between subsurface oil bearing formations and the atmosphere.

In two similar incidents, occurring in July, 1971 and January, 1973, damage to oil storage barges caused spills of 7,100 bbl. of oil into the sea before the cargo could be offloaded onto another barge.

c. Minor Spills

The requirement for reporting minor spills (less than 50 bbl.) and slicks of unknown origin was put into effect in 1969. From 1970, the first full year of minor spill records, to the present, the number of minor spills reported has remained almost constant, but the total volume of spills has decreased each year. The following table (Table 47), furnished by the Geological Survey, lists annual totals of minor spills by number, volume, and source, and also lists the number of slicks sighted.

Table 47.

MINOR OIL SPILLS

Year	Total Number Reported	Source by Number Drilling	Source by Number Pro.& Trans.	Total Volume (Bbl.)	No. Oil Slicks Sighted, Not Ident. by Source
1970	1,200	4	1,196	2,597	745
1971	1,250	13	1,237	2,414	878
1972	1,158	13	1,145	1,812	606
1973	1,392	10	1,382	1,857	958

Oil slicks from unidentified sources are not positively related to offshore drilling, transportation, or production. There is evidence of natural oil seepage in the Gulf of Mexico, first recorded in 1906, long before oil development activities were initiated, and seepage still persists in oil prone areas. It is possible that these natural seeps could be the source of some slicks classified as being from an "unidentified source". Other possibilities are ships bilges and tanker cleanings.

We are optimistic about the industry's performance in cleaning up its routine operations and decreasing the amount of chronic spillage. The trend becomes obvious when total minor spills in barrels per month are plotted against time, as has been done in Figure 53. The smooth curve represents a constant percentage (1.93%/mo.) decline based on the plotted data. During the period 1970-73 total oil and condensate production varied by less than 13% whereas the constant percentage decline curve represents a decrease in minor spill volume of 60% over the same period.

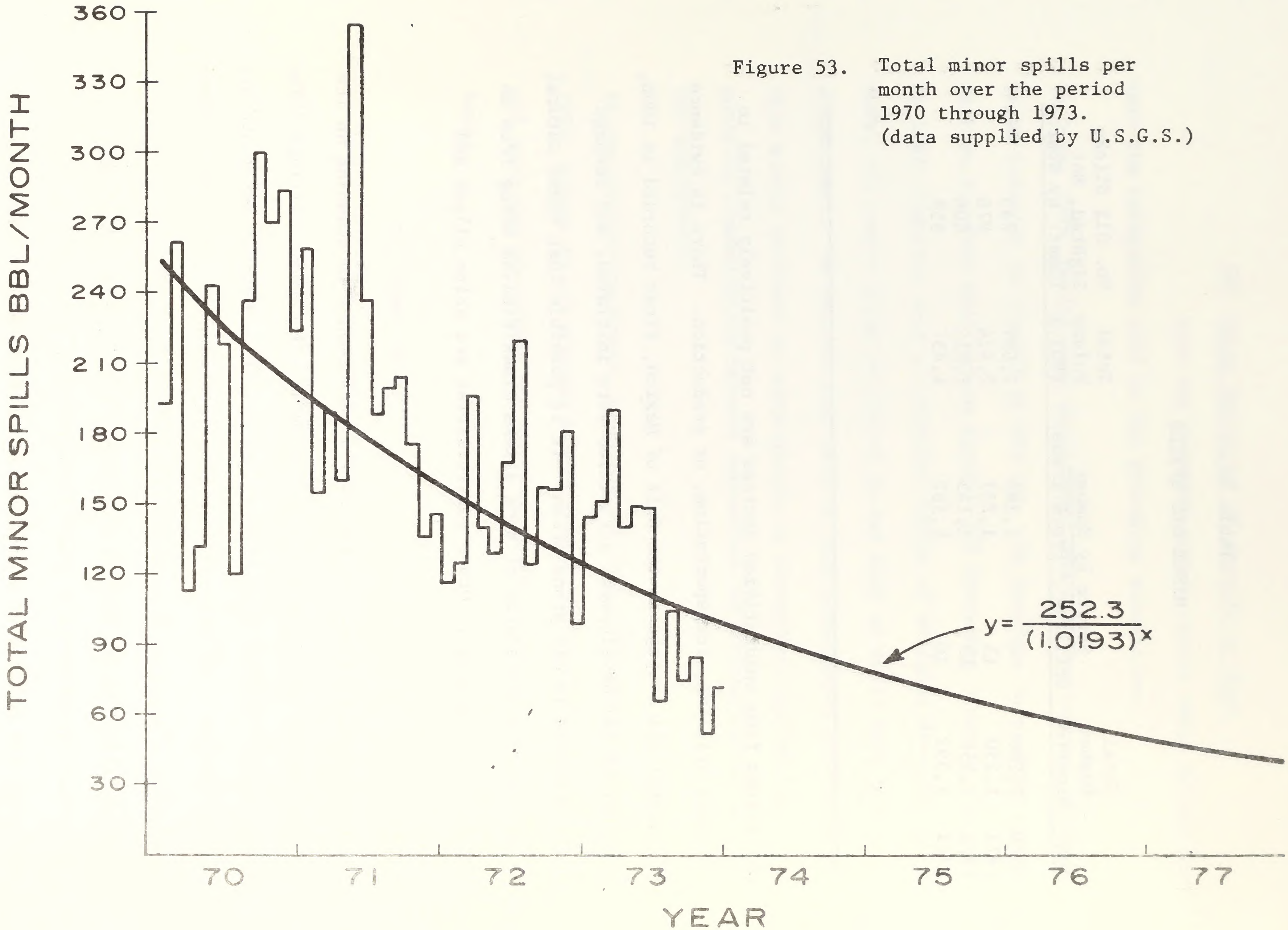


Figure 53. Total minor spills per month over the period 1970 through 1973. (data supplied by U.S.G.S.)

If a total of 8,680 bbl. of petroleum liquids were spilled during the years 1970-73, and 1,488,242,300 bbl. were produced during the same period, the spillage rate was 0.000583%. Projecting this rate to the present proposal, where maximum production is estimated at 45,625,000 bbl/yr., it seems valid to predict a maximum minor spill level at about 42 bbl./yr. If the downward trend of minor spill volumes, as shown in Fig. 53, continues, the figure will be somewhat smaller. By definition, the maximum size of a single minor spill, of course, is less than 50 bbl.

d. Collisions Resulting From Conflict Between Ship Navigation and Offshore Structures

During the period July 1, 1962 through June 30, 1971, the Coast Guard recorded 24 incidents of collisions between vessels and fixed platforms. Total damages were estimated to be about $0.4 million to vessels and $3.4 million to the structures. Only four injuries and no deaths were reported. Of these, eight accidents involved vessels of over 1,000 gross tons. These eight accidents accounted for $87 thousand of vessel damage (only four vessels reported damage) and over $3.2 million damage to platforms and no injuries or deaths reported. Five of these accidents occurred at night (three within two hours of midnight) and two during day-light. All of the eight major accidents occurred outside established shipping fairways and anchorage areas and only three were less than five miles from these established areas. At least five of the accidents involved foreign flag vessels. The worst of these eight accidents occurred in 1967

when a 11,600 ton foreign flag cargo vessel collided with a platform in Ship Shoal Area Block 214 at 1:30 a.m. during heavy rain, poor visibility, 45 knot winds and 15-20 foot seas. The vessel escaped with damages estimated at $12,000 but damages to the platforms were of the order of $1.1 million or 1/3 of the total damages in all eight accidents. Nearly one year following this collision a blowout of gas and condensate occurred on this platform. There was a minimal amount of oil spilled because the well was producing gas.

The remaining 16 incidents of collision between vessels (less than 1,000 gross tons) and platforms caused more damage ($290 thousand) to the vessel than to the platforms ($100 thousand). Causes were assigned as 2-weather, 8-vessels and 6-platforms; the platforms causes were further defined as 3-equipment failures, 2-insufficient or improper lighting and 1-improper maintenance.

During the time period 1957-1971, the Geological Survey recorded only one significant spill of oil, 2,560 bbl., associated with ship-platform collisions, as discussed in subsection b. (6), above.

e. Accidental Deaths and Injuries on Oil Industry Structures and Vessels

Information supplied by the U.S. Coast Guard reveals that a total of 100 individuals were killed as a result of accidents involving construction, supply, and drilling vessels, workboats, mobile drill rigs, and artificial islands in the Gulf of Mexico and

adjacent navigable inland waters during the period 1964-1973. Of these 100 deaths, approximately 66 occurred in water approximately equal to the Federal OCS area. Table 48 on the following page, provided by the Coast Guard, shows these casualties by source and year. These figures do not include deaths resulting from accidents in which no vessel or rig damage occurred (i.e., persons falling, or knocked overboard, crushed by drilling equipment, etc.). Since complete data is not available for the years 1964-1966, only the data from 1967-73 will be used as a basis for the following predictions.

Deaths due to offshore oil and gas operations involving vessel damage totalled 68 from 1967-73. Of these, 41 took place in international waters and 27 in inland waters. In addition, 35 persons were killed in oil operations in the Gulf of Mexico (both inland and international) with no casualty to the vessel being involved. Using the 41:27 ratio based on deaths involving vessel damage, we estimate that 21 of the 35 deaths not involving vessel damage will occur in international waters. This gives a new total of 62 deaths occurring in international waters from causes related to OCS oil and gas operations. Based on this information, approximately 9 deaths per year may be expected in the Gulf of Mexico as a result of offshore industry activity in OCS waters.

Table 48. Total Deaths Reported as Resulting from Vessel Casualty

	Inland Waters Gulf of Mexico										Gulf of Mexico									
	Fiscal Years																			
	64	65	66	67	68	69	70	71	72	73	64	65	66	67	68	69	70	71	72	73
Mobile Drill Rigs and Artificial Islands	No info		-	7	-	12	-	-	-	-	No info		-	-	2	1	7	14	6	1
Oil Industry Supply Vessels and Workboats	-	-	-	-	-	-	3	2	-	-	-	-	2	-	-	-	-	4	-	-
Oil Industry Construction And Drilling Vessels	4	1	2	1	-	2	-	-	-	-	22	1	-	1	-	-	2	3	-	-
Sub Total	4	1	2	8	-	14	3	2	0	0	22	1	2	1	2	1	9	21	6	1
Total 101																				

Below is listed a summary of injuries reported to the Office of Workmen's Compensation Programs under the Outer Continental Shelf Lands Act by district. 1/ The years are recorded as fiscal years (Table 49).

1/ U.S. Dept. of Labor.

Table 49. Total Injuries Reported Under the OCS Lands Act

ALL DISTRICTS

	Cases Reported		
Fiscal Year	Non Fatal	Fatal	Total
1968	3,583	28	3,611
1969	3,395	25	3,420
1970	3,261	21	3,282
1971	2,822	32	2,854
1972	1,975	14	1,989
1973	2,307	21	2,328
DISTRICT 7 - NEW ORLEANS			
1968	2,772	25	2,797
1969	2,578	17	2,595
1970	2,777	12	2,789
1971	2,664	30	2,694
1972	1,788	11	1,799
1973	2,214	21	2,235

3. Impacts Which Can Be Minimized or Avoided by Regulations and Safe Operating Practices

A more thorough discussion of regulations and operating orders is presented in section V, "Mitigating Measures Included in the Proposed Action".

4. Summary of Impacts

The preceeding sections describe the source and amount of both intentional and unintentional discharges which will pollute the sea and ocean floor if this proposed lease sale is held. It is the intent of this section to summarize all predicted polluting discharges in tabular form (Table 50). Two features should be pointed out prior to consideration of the tabular values.

(1) All pollution sources will not be present throughout the life of the leases; e.g., exploratory drilling will be completed within 4 years of leasing, developmental drilling, within 7, and production will not begin until the third. "Deep" water tracts may take slightly longer to reach the production phase. The reader is reminded of the timetable and discussion in Sec. III.A.6.

(2) The text of the preceding sections contains estimates of maximum pollution anticipated based on the maximum number of wells and amount of production. The table included here shows a range of pollution anticipated, based on the range of production predicted by the Geological Survey (70,000-125,000 bbl. of oil per day or 300 million-700 million bbl. per year).

GPO 875-501

Table 50. PREDICTED POLLUTION FROM DEVELOPMENT AND OPERATIONS OF OIL AND GAS LEASES OCS SALE # 36

Pollution Source	Pollutant	Duration	No. Incidents Low	No. Incidents High	Volumes Low	Volumes High	Units
Well Drilling	Drill Cuttings	Exploratory - 0-4th year Development 3-7th year	700 (wells)	900	270,000	765,000	tons
Well Drilling	Mud Chemicals	Same as above	700 (wells)	900	30,000	380,000	tons
Total drill cuttings and mud chemicals discharged into sea					300,000	1,145,000	tons
Produced Formation Water	Brine/Oil	3rd yr - life				603,000 1/	bbl/day
Pipeline Leaks	Oil	3rd yr - life	0	3/yr	0	3,000	bbl/yr
Blowouts (Drilling)	Oil	0 - 7th yr	0	1	0	2/	
Platform Fires & Explosions	Oil	3rd yr - life	0	1/yr	0	1,370	bbl/ incident
Hurricane Damage	Oil	3rd yr - life	1/yr	3/yr	84	200	bbl/yr
Equipment Failure/ Human Error	Oil	3rd yr - life	2/yr	5/yr	13	27	bbl/yr
Ship Collision	Oil	Life	0	1/yr	0	42	bbl/yr
Minor Spill (50 bbl)	Oil	Life	100/yr	150/yr	112	266	bbl/yr
Maximum amount oil which could be spilled into sea					4,905 3/		

1/ Total for all current Louisiana OCS operations - approximately 305,000 bbl/day transported to shore.

2/ Too many factors involved to make meaningful prediction. No "annual" volumes concerned.

3/ Does not include oil associated with formation water; represents peak of production, not developmental or declining years.

WEST CAMERON AREA
EAST CAMERON AREA
VERMILION AREA
SOUTH MARSH ISLAND AREA
EUGENE ISLAND AREA
SHIP SHOAL AREA
SOUTH TIMBALIER AREA
SOUTH PELTO AREA
GRAND ISLE AREA
WEST DELTA AREA
BRETON SOUND AREA
CHANDELEUR SOUND AREA
CHANDELEUR AREA
CHANDELEUR AREA EAST ADDITION
MAIN PASS AREA SOUTH & EAST ADDITION
MAIN PASS AREA
MAIN PASS AREA EAST & SOUTH ADDITION
SOUTH PASS AREA
SOUTH PASS AREA SOUTH ADDITION
WEST DELTA AREA SOUTH ADDITION
GRAND ISLE AREA SOUTH ADDITION
SOUTH TIMBALIER AREA SOUTH ADDITION
SHIP SHOAL AREA SOUTH ADDITION
WEST CAMERON AREA SOUTH ADDITION
EAST CAMERON AREA SOUTH ADDITION
VERMILION AREA SOUTH ADDITION
SOUTH MARSH ISLAND AREA SOUTH ADDITION
EUGENE ISLAND AREA SOUTH ADDITION
MOBILE SOUTH NO 2
GARDEN BANKS
NEW ORLEANS SOUTH NO. 1
TRACTS UNDER CONSIDERATION FOR POSSIBLE LEASING (#36)
LOCATION DIAGRAM
Mobile South No. 1
New Orleans
Mobile South No. 2
Garden Banks
New Orleans South No. 1
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
OIL AND GAS DEVELOPMENT MAP OF THE
GULF COAST
STATE OF LOUISIANA
OUTER CONTINENTAL SHELF
SCALE 1"=40,000'
STATUTE MILES
OCS- 2/13/74

GPO 875-363